Pentachlorophenol (PCP) Thermal Wood Preservation Facilities

Recommendations for Design and Operation

Report EPS 2/WP/5
April 1988

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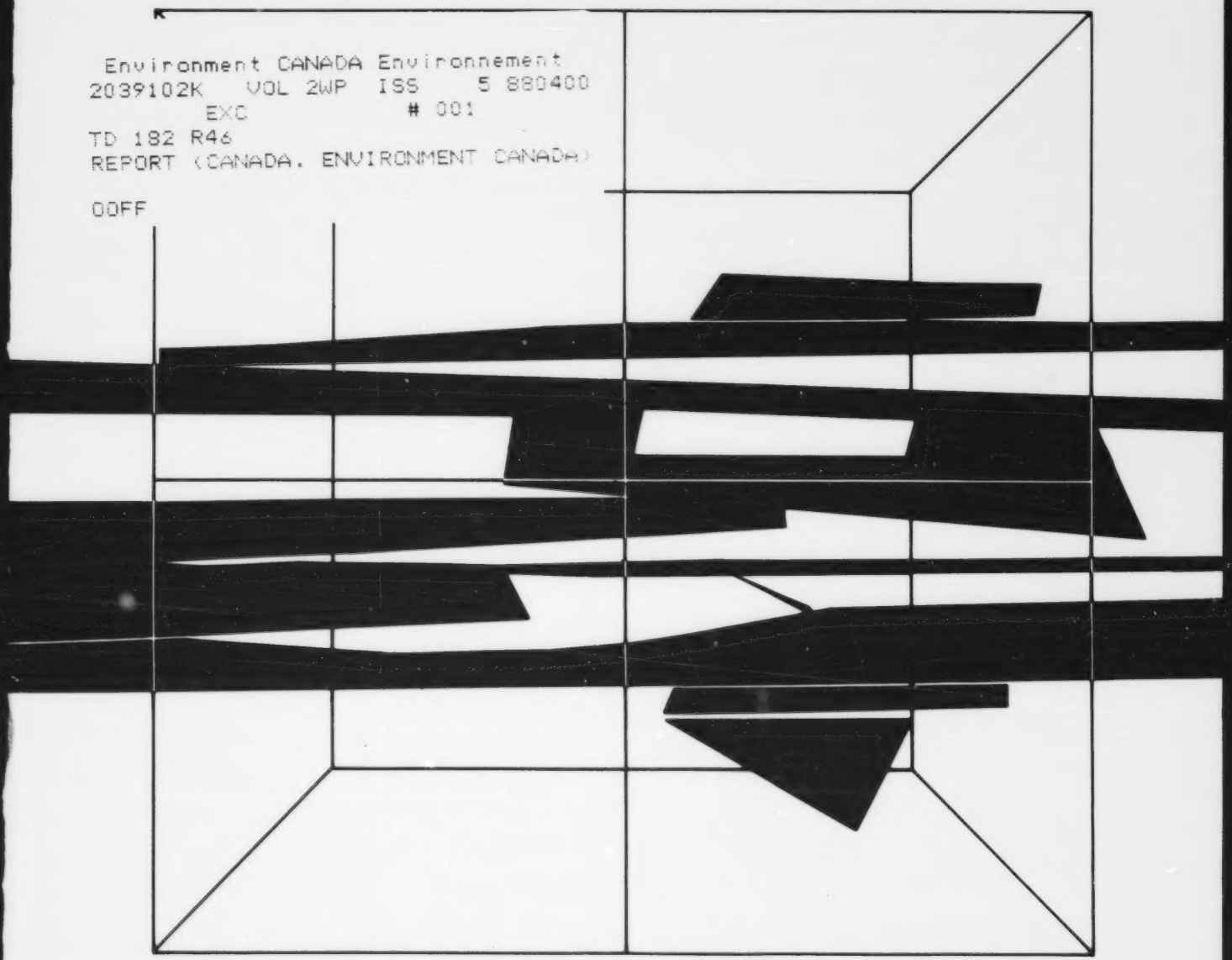

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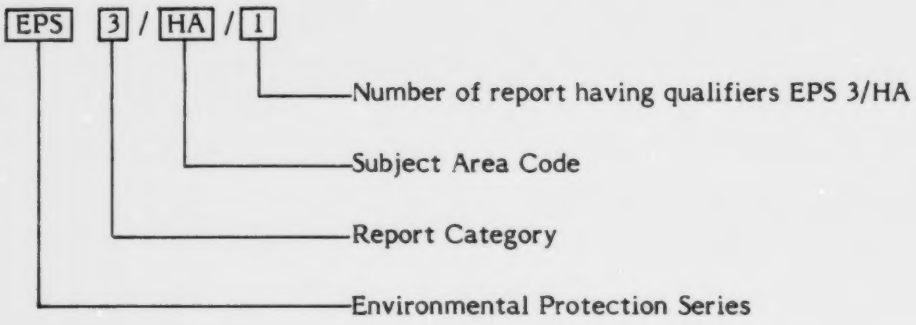

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PENTACHLOROPHENOL THERMAL WOOD PRESERVATION FACILITIES

Recommendations For Design And Operation

prepared by

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under the direction of the

Wood Preservation Industry Technical Steering Committee

for

Conservation and Protection
Environment Canada

Report EPS 2/WP/5
April 1988

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FOREWORD

As part of a federal strategy to protect the environment and human health from potentially toxic commercial chemicals, Environment Canada has evaluated chemical use practices within the wood preservation industry. During 1982-1984, Envirochem Services were retained to visit and review practices at 19 wood preservation facilities operating in four provinces, and to document the findings. In July 1984, Environment Canada established the Wood Preservation Industry Steering Committee to develop technical recommendations for wood preservation facility design and for operational measures which would:

- reduce or eliminate the release of wood preservation chemicals to the environment; and
- eliminate harmful exposure of workers to wood preservation chemicals.

The Steering Committee included representatives from federal and provincial government agencies, wood preservation companies, and forest industry labour unions and workers' compensation boards (see page xi).

EnviroCHEM Services was subsequently retained to develop an initial draft technical recommendations document for review by the Steering Committee. During the review, input was also obtained from other experts in both industry and government. This technical recommendations report is the result of this comprehensive development and review process.

The design and operational measures presented are based on current knowledge of existing technology and of the physical, chemical and biological properties of technical grade pentachlorophenol (PCP). Although the recommendations are not part of any environmental legislation, they reflect the intent of the Federal Fisheries Act, and of provincial environmental and worker safety legislation and regulations.

The Steering Committee recommends that <u>new PCP thermal treatment facilities</u> comply with the objectives in this technical recommendations document. Although methods to achieve these objectives are provided, the Committee fully supports the option of industry to achieve those objectives using other design features or operational procedures that can be shown to be at least equally effective.

The Steering Committee recommends that <u>existing facilities</u> modify their operations as much as possible to meet the objectives of the recommendations. Site-specific circumstances will influence the applicability and implementation of specific

measures for achieving the objectives recommended in this document at both new and existing facilities. It is further recognized that the recommendations are based on existing knowledge, and ongoing and future studies may suggest the need for modifying these recommendations. The authors therefore recommend a definitive periodic review of the technical recommendations.

The Technical Steering Committee believes that the proper implementation of the technical recommendations will allow the continued beneficial use of pentachlorophenol as a wood preservative and will protect both the environment and workers from potential harmful effects.

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1 THE NEED FOR WOOD PRESERVATION

1.1 Introduction

Wood preservation is the pressure or thermal impregnation of chemicals into wood to a depth that will provide effective long-term resistance to attack by fungi, insects, and marine borers. By extending the service life of available timber, wood preservation reduces the harvest of already stressed forestry resources, reduces operating costs in industries such as utility and railroad companies, and ensures safe working conditions where timbers are used as support structures.

The chemicals predominantly used in Canada for wood preservation are (1, 2, 3):

- pentachlorophenol,
- creosote, and
- aqueous formulations of arsenic, copper, and chromium or ammonia.

The wood preservation process deposits or fixes these chemicals in the wood, and the toxic nature of the chemicals effectively prevents the attack of living organisms on the wood. Because the chemicals are also toxic in varying degrees to humans and aquatic organisms, their use in industry must be carefully controlled. This document is intended to provide consistent guidelines for the design and operation of wood preservation facilities in a manner that will protect workers and the environment from harmful exposure to wood preservation chemicals.

1.2 Wood Deterioration

Timber is subject to several types of deterioration following its removal from the forest. Wood-decaying fungi and insects drastically reduce the usefulness of unprotected lumber and other forest products. As an example, untreated timbers used in underground workings of mines could have a lifetime of no greater than two years because the temperature and moisture conditions in mines favour decay. Another example is the railway cross-ties used in North America, which would have an average lifetime of five years without treatment. Protection is also required against wood-boring insects. For example, termites are responsible for extensive damage to wood in storage and in service. Marine structures such as untreated dock pilings along the North American coast can be destroyed by marine borers in less than one year.

The growth of wood-destroying fungi depends upon temperature, oxygen level, the moisture content of the wood and the nature of the food source (the wood). Wood products such as railroad ties, bridge and mine timbers, and utility poles are usually in direct contact with moist soil or in locations where moisture collects and cannot readily evaporate. When there is no practical means of limiting moisture content, oxygen levels or temperature, the option for the protection of such wood products is limited to the application of chemicals which act as agents to limit fungal growth by "poisoning" the wood food source. Simultaneously, the treatment can limit the activity of other wood-destroying organisms such as insects and wood-borers.

1.3 Wood Preservation Chemicals

Historically, the preservation of wood by chemical means can be traced back over 4000 years, to the time when the Egyptians apparently used bitumen to treat wooden dowel-pins in the stonework of temples (4). At the time of the Roman Empire, tar, linseed oil, oil of cedar, and mixtures of garlic and vinegar were used for the preservation of wooden statues. Alexander the Great of Persia is reported to have ordered piles and other timber for bridge building to be covered with olive oil as a precaution against decay (5). Investigations to define alternative wood preservation agents were reported in the late 1600s with escalating efforts during the 1800s. A review of the many chemicals and chemical formulations used historically and currently can be found in the above references and in texts such as those written by Hunt and Garratt (6) and Wilkensen (7).

The choice of wood preservative depends upon the character of the wood to be treated, the required service, and the properties of the chemical or formulation. Wood preservation formulations must:

- be toxic to attacking organisms;
- be able to penetrate wood;
- be chemically stable;
- be safe to handle;
- be economical to use;
- not weaken the structural strength of the wood; and
- not cause significant dimensional changes within the wood.

Other factors which determine the selection of wood preservation chemicals or formulations include: fire resistance; color or odour; paintability; corrosiveness; electrical conductivity; and, leachability from wood.

In Canada, the predominant wood preservative chemicals or formulations in use are:

- CCA (chromated copper arsenate). Major CCA-treated products include: fence posts, lumber for patios and landscaping, and foundation lumber and plywood.
- ACA (ammoniacal copper arsenate). Major ACA-treated products include: utility poles and landscaping timbers.
- PCP (pentachlorophenol). Major PCP-treated products include: railway ties and utility poles.
- Creosote. Major uses include treatment of railroad ties, utility poles, and marine pilings.

Although other wood preservatives have been used in the past in Canada, the four chemicals or formulations noted above are the only preservatives in use in Canada since 1985. The development of alternative chemicals for wood preservation is the subject of ongoing research. The actual use of alternative chemicals will depend on industry and safety evaluations, and on approval under the Federal Pest Control Products Act administered by Agriculture Canada.

1.4 The Value of Wood Preservation

Controlled studies have shown that wood preservation enhances the lifetime utility of wood by a factor of 5 to 15, depending on the wood species, use and efficacy of treatment. It has been estimated that, if in the U.S.A. "untreated wood were used for the applications now employing preservative-treated wood, the added annual cost to the transportation, utility, and construction industries would be over $15 billion dollars. Energy savings, depending on the substitute materials envisioned, are from 19 to 32 million barrels of petroleum per year" (8).

It has also been estimated that if wood were not treated with preservation chemicals, timber requirements would increase by three- to six-fold. Such requirements would have exhausted many timber industries (6). Wood preservation also enables the use of smaller and faster growing trees such as lodgepole pine. Prior to the widespread use of wood preservation, timbers used in structures such as railway bridges were required to be over-sized in order to accommodate a degree of decay.

2 OVERVIEW OF PENTACHLOROPHENOL THERMAL TREATMENT FACILITIES

2.1 Description of Process

PCP dissolved in oil is the only wood preservation chemical used at thermal treatment facilities in Canada. Discussions and recommendations in this document are therefore limited to the use of PCP in thermal operations, although the objectives would be applicable to any alternative wood preservative chemical that may be used in the thermal process.

Wood preservation requires that chemical agents, such as PCP, penetrate several centimetres into the wood. Thermal treatment (as shown in Figure 2.1) is used to achieve penetration and subsequent fixation of the chemical agent within wood. The process can be used to treat entire lengths of timbers or only the "ends" of poles (butt treatment). The latter type of treatment would be used for the protection of only the portion of the utility pole that normally is placed below ground level.

PCP is purchased in granular or flaked form in 23-kg (50-lb) bags, or in solid blocks, usually in 454 and 907 kg (1000 and 2000 lb) weights. Petroleum oils used as carriers for PCP are delivered by bulk truck or rail tanker and stored in tanks. Following delivery of PCP and the carrier oils, the following process steps occur.

2.1.1 Chemical Mixing. PCP blocks are lowered into a thermal treatment tank. Hot petroleum oil is circulated between the tank and a PCP/oil storage tank until a dissolved solution is attained. Bags of PCP flakes may be used to increase PCP concentrations to desired working levels, e.g., 5% PCP. The prepared solution is then transferred to an insulated storage tank.

2.1.2 Wood Preservation. Prior to application of the PCP-carrier oil mixture, the moisture content of the wood must be reduced to a suitable level. Air-seasoning is used to reduce moisture in wood prior to treatment in Canadian thermal treatment plants. Prior to treatment the wood products may be incised or drilled to customer specifications. Poles are the most common thermally treated product. The poles are then loaded into horizontal, rectangular tanks for full-pole treatment, or into cylindrical tanks for upright butt treatment of pole ends, using cranes or custom forklift equipment. Poles placed in the horizontal full-length tanks are held in place by steel cross beams. Full length tanks are normally covered with plywood or steel lids prior to application of the preservative. Typical dimensions of such tanks are 4 m x 4 m x 30.5 m.

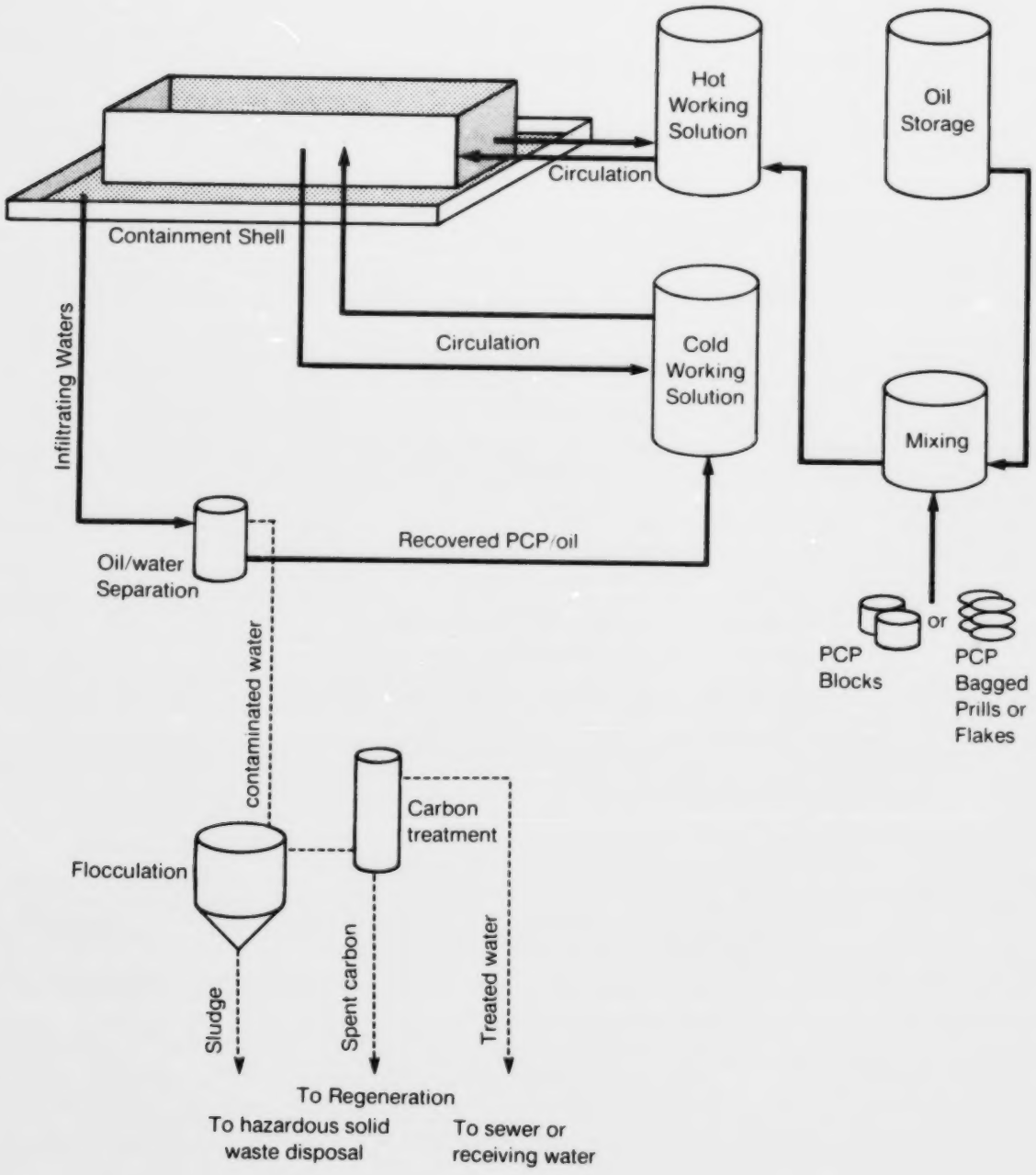

FIGURE 2.1 PROCESS FLOW DIAGRAM OF PCP THERMAL TREATMENT PLANTS

2.1.3 Preservative Application. Thermal treatment is analogous to the full-cell pressure treatment process. The treatment cycle consists of the following steps:

a) flooding of the tank with hot oil at 104 to 110°C (220 to 230°F);
b) immersion of the wood in the hot oil until the interior is heated throughout (generally two to ten hours);
c) transfer of the hot oil to a storage tank and flooding of the treatment tank with "cold" PCP-oil mixture at 52°C (125°F) for one to six hours to create a partial cell vacuum and enhance absorption of PCP-oil into the wood cells during the contraction of the wood;
d) return of the "cold" oil to a storage tank; and
e) return of the hot oil as a "hot wash" to remove excess preservative from the pole surface.

The poles are left in the treatment tanks to cool and to allow any excess preservative to drip off. The poles are then inspected and cored for quality control purposes.

In butt treatment, the wood is held vertically with only a portion of the pole submerged in oil. Butt dip tanks cannot be covered during treatment but the exposed oil surface area is limited.

Specific treatment times and temperatures are stipulated by CSA standard 080 (9) and vary with the species and moisture content of the wood.

2.1.4 Storage of Treated Product. The cooled, treated wood is moved from the treatment tank to a storage area, or loaded directly into railcars or trucks for shipment.

2.2 Potential Chemical Releases

Thermal wood preservation facility design and operational practices vary (1,2,3), and each facility has potential sources of emissions that may affect worker health and/or the environment. The potential sources and releases are illustrated in Figure 2.2. Section 8 of this report provides a more detailed discussion of the potential chemical releases and control/disposal options.

2.2.1 Liquid discharges. Although no liquid process wastes are produced during thermal treatment, the following situations could create liquid releases:

- spills or overflows of liquid from open treatment tanks;
- infiltration of groundwater into tank containment systems;

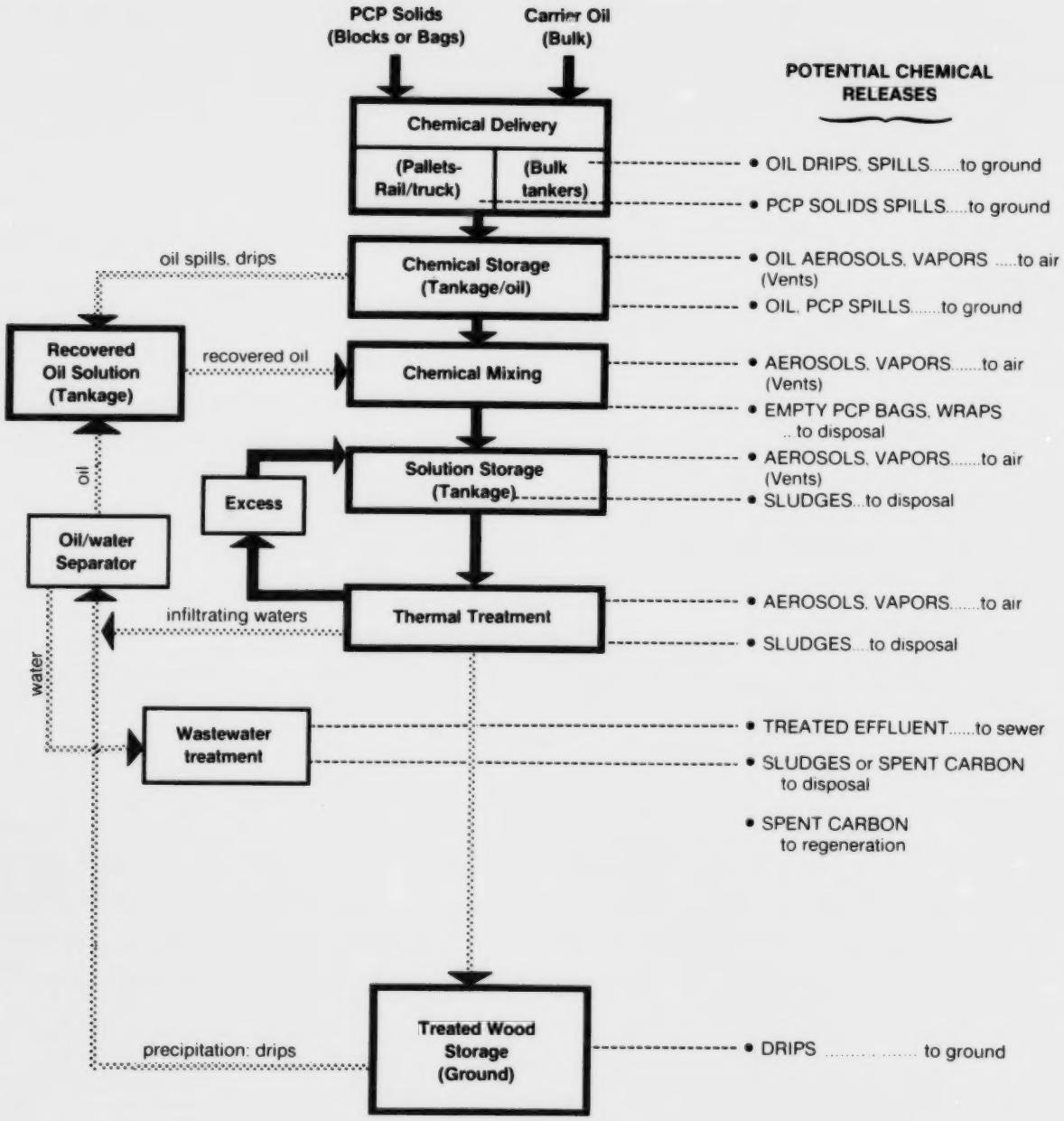

FIGURE 2.2 POTENTIAL CHEMICAL RELEASES FROM PCP THERMAL TREATMENT PLANTS

- leaks from treatment tanks that have no containment provisions; and
- surface runoff from the treated wood storage areas.

The need for control of runoff waters would depend on analytical and/or bioassay evaluations, and on regulatory requirements.

2.2.2 Solid Wastes. Solid wastes from oil-borne PCP thermal treatment facilities include:

- sludges from treatment and storage tanks, in particular the "cold" PCP/oil storage tank;
- sludges from wastewater treatment processes (e.g., flocculated material); and
- bags, containers or wrappings from bulk PCP.

Disposal methods for solid wastes are recommended in Section 8.

2.2.3 Air Emissions. Air emissions from thermal treatment facilities are localized and intermittent, and include:

- vapours which escape from the treatment tanks during the treatment cycle;
- vapours from tank vents;
- dust from manual debagging of PCP; and,
- vapours from freshly treated charges.

Emissions that could disperse beyond facility boundaries include:

- vapours from uncovered treatment tanks during the treatment cycle, and
- combustion products from open-burning of sludges.

Open-burning of PCP sludges is discouraged by most provinces in Canada.

2.2.4 Potential Effects. The actual impact of any chemical on the environment depends upon many factors, including the location of the wood preservation facility relative to ground or surface waters, the species of aquatic biota in adjacent surface waters, and the amount of preservative released. Variables that can influence effects on worker health include ambient concentrations, frequency of exposure and protective measures during the time(s) of exposure.

All PCP manufacturing and user facilities could affect the environment, as could all other types of chemical manufacturing and chemical user industries if proper control measures are not in place. Documented PCP releases from wood preservation facilities have been due to either poor design or poor operating practices. The effects of these releases appeared to be either localized within the plant site (i.e., soil and groundwater contamination) or in the environment immediately adjacent to the plant site.

The literature and government documents make no reference to environmental assessments of Canadian PCP thermal treatment facilities. The facilities have had low assessment priorities because only four plants are operating in Canada, and they are remote from populated and environmentally sensitive areas (3). Extensive cleanup measures have been required at two facilities in the United States because of historical releases (10,11).

Although no fires are known to have occurred at Canadian PCP thermal facilities, incidents of fires at three Canadian PCP pressure facilities illustrate the need for proper contingency planning for fire control and for containment of oil solutions and fire runoff waters.

Human health could be affected if proper precautions are not taken during handling of PCP, exposure to minor spills and residues in working areas, exposure to vapours or during handling of treated products. More detailed discussions of the potential effects of releases of PCP are found in Sections 3.3 and 3.4.

2.3 Chemical Management at PCP Thermal Treatment Facilities

The design and operational practices for control of PCP at thermal facilities vary. Newer facility designs reflect an increased awareness of the need for chemical control. Older facilities may compensate for design limitations through operational controls (1). Environment Canada surveys have found that no technical support from PCP manufacturers or distributors was evident at thermal facilities (1,2,3). As a result, detailed design and operating practices were found to be highly individualized at each facility.

The contractors who conducted the Environment Canada survey characterized the industry segment as highly variable in the overall control of PCP (3). The variability was attributed to:

Differences in design features for:

- containment of thermal treatment tanks (all of which are sub-surface),
- control of vapours from treatment tanks, and
- auxiliary equipment for the handling and mixing of PCP.

Differences in operational procedures, including:

- housekeeping requirements and equipment maintenance,
- training of personnel, re routine and emergency situations,
- protective measures in vicinity of thermal tank vapours,

- sludge disposal,
- requirements for pre-employment medical examinations (to determine sensitivity of individuals) and periodic ongoing medical surveillance, and
- monitoring of chemical losses to the workplace and the environment.

Discussions with U.S. regulatory personnel and U.S. users of thermal treatment revealed that, where releases from thermal treating plants have occurred, the environmental effects have been limited to site soil and groundwater contamination (10,11). North American health studies, although few, have not revealed serious worker health problems (12,13,14,15). Nonetheless, monitoring of workers at some thermal facilities has shown evidence of higher exposure to PCP than workers at pressure treatment facilities (13,16).

In an overview assessment of the industry, the contractors for the Environment Canada surveys noted that exceptions to "good" control of chemical releases did exist and, in such cases, improvements in physical facilities and/or operational procedures would be desirable to protect human health and the environment (3). The surveys were limited to "walk through" assessments at two of the four Canadian thermal treatment operations and review of existing regulatory monitoring data. Although health monitoring data were available (16) for three of the sites, no environmental monitoring data were found (3). Nonetheless, the surveys suggested that "with reasonable safeguards, the likelihood of environmental and human health impact could be reduced to nil" (3). This document defines objectives for the protection of the environment and workers from potential harmful effects of PCP and suggests means of achieving these objectives within the industry.

3 PENTACHLOROPHENOL

3.1 Production and Use

PCP (pentachlorophenol)* was first used as a wood preservative in 1936 (17). The biological properties of PCP have resulted in its use in other industries, e.g., as an anti-microbial agent in industrial cooling systems and papermaking, and as a fungicide in protein-based latex paints (18). A 1981 survey of PCP usage in Canada revealed that the wood preservation industry was the largest user of PCP, consuming 1536 metric tonnes of the 1600 metric tonne total Canadian consumption (19). It was estimated that 85% of the 1536 tonnes were used at pressure treatment facilities, with the remainder used at thermal treatment facilities. Quantities of PCP used by the wood preservation industry depend primarily on the size of the pole market; the market has been reasonably stable in the past. Table 3.1 provides an overview of PCP usage at Canadian thermal treatment facilities.

PCP is prepared by reacting chlorine with phenol in the presence of a catalyst at high temperatures. PCP was last manufactured in Canada in 1983. Since 1986, Canadian users have obtained PCP from either of two European manufacturers or from one U.S. manufacturer. PCP is sold either in flake (prill) form (in 23-kg or 50-lb bags) or in block form (900-kg or 2000-lb solid blocks) (20). All thermal treatment facilities surveyed in the 1984 Environment Canada studies purchased the blocks as a principal source of PCP and the flake form for small adjustments of PCP concentration in oil (1,2,3). The petroleum oils used as carriers for PCP are purchased from Canadian sources. The oils must conform to CSA standard 080.201-1983.

PCP-oil mixtures are used primarily for thermal treatment of wood products, primarily telephone and utility poles. Thermal treatment may be used to treat the entire length of the pole or only the "butt" of a pole, i.e., that portion which is placed below ground level. The thermally impregnated PCP is retained by the wood, and its toxicity protects the wood against fungi and insects. In addition to functioning as a carrier of PCP, the oil also provides extra protection against moisture-content changes, providing more stability and resistance to splitting.

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* The technical product referred to as "PCP" in this document is not pure PCP. It contains 86% PCP and 10% "other chlorophenols and related products". Use of the term "PCP" in this document is consistent with industry nomenclature, and refers to the technical grade product.

TABLE 3.1 OVERVIEW OF PCP USAGE IN CANADA (Thermal treatment facilities)

Feature	Characteristics
Delivery format	23-kg (50-lb) bags (flakes or prills) 135 and 200 kg (300 and 450 lb) drums (flakes or prills) 1-tonne boxes (flakes or prills) Rail car quantities (flakes or prills) 454 or 900 kg (1000 or 2000 lb) blocks (solid blocks)
Concentration of active ingredients	Described by manufacturers as: "86% PCP, 10% other chlorophenols and related compounds, and 4% inerts"
Suppliers to Canadian facilities (1986)	Vulcan Materials Co., Birmingham, Alabama Rhone-Poulenc, France Dynamit-Nobel, Germany (ceased production 1986)
Estimated use by Canadian facilities (1986)	200 000 kilograms (estimated)
Concentration of work solutions	3 to 6% PCP in petroleum oil
Typical preservative retention in treated wood	6.4-12 kilograms PCP-oil/cubic metre treated wood (0.4-0.75 pounds/cubic foot);
Major products treated in Canada	Utility poles

3.2 Physical and Chemical Properties

PCP is a solid at room temperature. It can be characterized as a stable organic compound, which is sparingly soluble in water and highly soluble in organic solvents. It adsorbs strongly to organic solids such as cellulose in wood.

PCP is chemically and biologically persistent in high concentrations, e.g., the 3-6% concentrations used for treatment of wood. Its persistence in treated wood and its toxicity to wood decay organisms, are two major reasons for the use of PCP as a wood preservative.

Table 3.2 summarizes the physical and chemical properties of PCP (21,22). The physical and chemical properties cited below must be given special consideration during handling and contingency planning:

TABLE 3.2 PHYSICAL AND CHEMICAL PROPERTIES OF PENTACHLOROPHENOL SOLIDS

Identification

Common Synonyms: (past and current)	Chlorophen Cryptogyl 01 Dowicide 7 Dowicide G Penchlorol	Penta PCP Santobrite Santophen 20 Witophen P	Manufacturers:	• Vulcan Materials Co. (Birmingham, Alabama) • Rhone-Poulenc (Paris, France) • Dynamit-Nobel (Germany) (ceased production in 1986)

Transportation and Storage Information

Shipping State:	Solids (Blocks, flakes, prills)	Storage Temperature: Ambient Inert Atmosphere: Not required	Labels and classification: Check with the Department of Transport
Concentration:	96% by weight total chlorophenols (86% PCP)	Venting: Open	
Classification:	Poisonous	Containers/Materials: Bags or solid blocks with polyethylene wrap	

Physical and Chemical Properties

Physical State:	Solid	Floatability: Sinks in water	Appearance: White to light brown solid
Solubility:	Freely soluble (oil) Slightly soluble (water) 5 ppm by weight (0°C) 14 ppm by weight (20°C) 35 ppm by weight (50°C)	Specific Gravity: 1.98 (22°C) Vapour Pressure: 0.00011 mm Hg (20°C) 40 mm Hg (211°C) Boiling Point: Decomposes at 310°C Odour: Strong pungent odour when heated Vapour Density: 9.2	Melting Point: 188 to 191°C Flash Point: Not flammable Explosive Limits: Not flammable

Hazard Data

Fire	Extinguishing Data:	Use water spray, dry chemical, foam or carbon dioxide. (Note: fire residues may contain chlorinated furans or dioxins, and must be treated as contaminated). Use water to cool fire-exposed containers.	**Reactivity**	With Water: No reaction With Common Materials: Can cause rapid deterioration of rubber when dissolved in oil. Stability: Stable
	Fire Behaviour:	When heated to decomposition, toxic fumes of hydrogen chloride are formed. Chlorinated dioxins may be generated.		
	Ignition Temperature:	Not combustible		
	Burning Rate:	Not combustible		

- the ability of PCP to dissolve in water, with increasing dissolution occurring with increasing pH and increasing temperature;
- the high solubility of PCP in oils, including skin oils which enhances its ability to penetrate skin following dermal contact;
- the potential to form toxic fumes upon exposure to fires and high temperatures (i.e., over 350°C); and
- a vapour pressure (although low at room temperature) which will result in a small degree of sublimation of PCP.

3.3 Environmental Effects

The exposure of aquatic organisms to PCP could result in both short-term (acute) and long-term (chronic) toxic effects. PCP is not considered a persistent contaminant in the environment because of documented photochemical degradation and microbial breakdown of low concentrations in surface waters, soil media and sewage effluents (23). However, as noted in Section 3.3.1, PCP is widespread at low concentrations in the environment, indicating that the above conclusions are not universal or that input rates exceed those of degradation (23). The environmental effects would be dependent upon a complex array of parameters including concentration, pH, adsorption to suspended solids, temperature, biodegradation rate, and photodecomposition rate.

3.3.1 Distribution in the Natural Environment. PCP has been detected in winter snowpacks, water, landfill leachates, sewage effluents, sediments, and in aquatic and terrestrial organisms (18,23,24,25). Many sources of PCP releases are suspected. These include the disposal of various commercial formulations used historically as slimicides and fungicides, storage areas for PCP-treated products (including lumber dipped or sprayed with chlorophenate solutions for sapstain control), accidental or uncontrolled process releases from wood preservation facilities, and chlorinated wastewaters, especially those from pulp and paper mills and municipal sewage treatment plants (23).

PCP is not a natural compound and its environmental background level should be "zero". However, anthropogenic sources have resulted in trace concentrations even in remote areas; for example, levels of 0.003 µg/L to 23 µg/L have been detected in many tributaries and bays of each of the Great Lakes. Supposed "remote" areas frequently showed levels of 0.01 µg/L (23). A survey of the Fraser River showed PCP concentrations ranging from 0.0020 µg/L to 0.0037 µg/L in waters sampled upstream of industrial areas (24). The reported trace concentrations illustrate the high degree of detection capability,

i.e., to a fraction of one-billionth of a gram PCP in a litre of water. These concentrations are much lower than concentrations which have been detected in aquatic biota and human drinking water (23,26).

3.3.2 Aquatic Toxicity. A large data base exists for the toxicity of PCP to aquatic biota and reviews are found in publications by Jones (18,19), the U.S. Environmental Protection Agency (26), and the International Joint Commission (23). Much of the published environmental and toxicity data on sodium pentachlorophenate (NaPCP) is also relevant to PCP and vice versa because PCP will be largely in its dissociated form at ambient pHs, i.e., pHs greater than 6 (23).

Table 3.3 summarizes observed values of chronic toxicity and acute toxicity of PCP to salmonid species such as trout and salmon. Chlorophenol compounds interfere with the basic metabolism of fish, leading to energy starvation. Acute effects (i.e., death) have been shown to occur in salmonids at PCP concentrations between 32 to 130 µg/L (parts per billion) over a four-day exposure (27). Exposure of fish to PCP concentrations in the parts per million range can cause death within minutes.

Prolonged low-level exposure of fish to PCP (at concentrations lower than reported acute concentrations) may lead to long-term (chronic) effects which are not immediately detectable. Chronic effects on fish include growth retardation and reproductive interference, which are caused by the effects of chlorophenols on the basic cellular metabolism. Diminished growth and reduced food conversion efficiency have been observed with long-term exposure of fish to PCP at concentrations as low as 1.7 µg/L (Table 3.3). Egg and larval development are also affected by low concentrations of PCP. Eggs of rainbow trout are particularly sensitive to PCP (10 µg/L) at low temperatures (28) and the development of marine mollusc larvae is affected at PCP concentrations of 7 µg/L (26).

Most of the above-mentioned toxicity tests used technical grade PCP, and the results are reported as per the U.S. Environmental Protection Agency recommendation that "criteria should treat PCP, including the impurities and their toxicities, as a single entity" (26). More recent data indicate that impurities enhance the toxicity of technical grade PCP. Cleveland et al. (29) reported a median lethal concentration (96-h LC_{50}) of 470 µg/L for fathead minnows exposed to purified PCP, versus a lower 96-h LC_{50} (205 µg/L) for fathead minnows exposed to technical grade PCP. Concentrations of purified PCP equal to or greater than 85 µg/L reduced the growth of the fathead minnows but did not adversely affect survival. Similar tests with technical grade PCP found

TABLE 3.3 AQUATIC TOXICITY OF PCP TO SALMONIDS

Pentachlorophenol Concentration micrograms/litre (parts per billion)	Effect*
1.7	Diminished growth rate. Diminished food conversion efficiency (Sockeye Salmon) (Ref. 12).
19	Juvenile mortality and growth effects observed (Ref. 27).
34	99% mortality of alevins (alevins are newly-hatched fish with yolk sacs) (Steelhead trout) (Ref. 27).
32 to 130	50% of the test fish were killed within 96 hours (equivalent to the median lethal concentration, i.e., the 96-hour LC_{50})**. (Rainbow trout, coho salmon, sockeye salmon, chinook salmon) (Ref. 24)
Data not available	96-hour LC_{50} of PCP-oil work solution.

* The aquatic toxicity of pentachlorophenol depends strongly on temperature and pH. Table 3.3 is illustrative only; detailed data on the aquatic toxicity of PCP can be obtained from reviews identified in the text.

** LC_{50} is defined as the concentration that results in death of 50% of the fish population within 96 hours.

reduced growth at concentrations of 13 µg/L or higher and reduced survival at concentrations of 27 µg/L or higher (29). Yolk sac edema and skull deformations, which are commonly observed in chronic tests with technical grade PCP, were reported as rare in tests with purified PCP (30). If the quality of PCP used by the industry is improved to the quality used in the above tests, then "the PCP toxicity data base may have to be reassessed and new data provided updating the criteria to reflect the changed toxicity resulting from the reduced impurity" (26).

3.3.3 Bioaccumulation. Although chlorophenols are usually substantially diluted upon entry into the aquatic environment, their limited chemical stability and persistence are sufficient to result in a moderate degree of bioaccumulation (accumulation in the tissues) in aquatic organisms. Reported ratios of PCP concentrations in fish tissue to concentrations in water (bioaccumulation factors) have ranged from 10 to 1640 (24). This

level of bioaccumulation is much less (e.g., 1000-fold less) than observed for organic compounds such as PCBs (polychlorinated biphenyls) and DDT (dichlorodiphenyltrichloroethane) (31). The relatively low bioaccumulation factor for PCP results from the ability of fish to rapidly excrete PCP and its metabolites (32). McKim et al. suggested that the "efficient elimination of PCP should allow vertebrates to tolerate periodic low doses of PCP without toxic effects" (32).

3.3.4 Environmental Criteria. Based on extensive reviews of the literature and unpublished information, regulatory agencies have derived upper limits for PCP in the environment. As of July 1987, upper limits for Canadian waters have been defined under the auspices of the following regulatory agencies or commissions: the International Joint Commission (IJC) for Great Lakes waters (23); Health and Welfare Canada for maximum acceptable concentrations in drinking water (33); the Ontario Ministry of Environment for protection of aquatic life; the British Columbia Ministry of Environment and Parks for waters of the Fraser River (34); and the Canadian Council of Resource and Environment Ministers (37). The upper limits are summarized in Table 3.4.

The proposed IJC limits are based on PCP toxicity to freshwater organisms and human health, and are intended to protect the most sensitive biological species within the Great Lakes ecosystem. The most sensitive response to PCP noted in experiments relevant to the Great Lakes ecosystem was growth inhibition of sockeye salmon underyearlings (23). The Health and Welfare Canada limitation is based on a total phenol concentration. Although the Department recognized that "halogenated phenol derivatives are highly toxic", the "taste and odour thresholds for phenols are very much lower than the toxic threshold, however" and "the maximum acceptable concentration is therefore based on aesthetic considerations" (33). The water quality objective of the British Columbia Ministry of Environment and Parks is applicable to the summation of tri-, tetra- and pentachlorophenol concentrations and is based upon the ministry's assessment of existing literature (34). The preface to the Canadian Council of Resource and Environment Ministers' report emphasized that its guidelines for PCP "do not constitute values for uniform national water quality and that their use will require consideration of local conditions" (37).

The U.S. Environmental Protection Agency's (EPA) most recent criteria for PCP concentrations in freshwater and saltwater were published in 1986 (35) and are summarized in Table 3.4. A prior statement of PCP toxicity was published by the EPA in 1980, but alternative criteria were not suggested and only an update of known lowest effect levels was provided (36). No evaluations have been made by Canadian agencies of

TABLE 3.4 REGULATORY LIMITATIONS FOR PCP IN NATURAL WATERBODIES

Limit Type	Limit Value	Basis	Agency
Maximum Acceptable[a]	2 µg/L	To protect drinking water (based on the odour threshold, which is more sensitive than the toxic threshold for man)	Health and Welfare Canada, 1978 (33)*
Recommended Maximum Concentration	220 µg/L	To protect human health (ingested with water)	U.S. Environmental Protection Agency, 1986
Objective	0.4 µg/L	To protect Great Lakes aquatic life	International Joint Commission 1980 (23)
Criteria	Examples[b] 5.5 µg/L at pH=6.5 20 µg/L at pH=7.8 68 µg/L at pH=9.0	To protect freshwater biota - one-hour average concentration not to exceed the calculated numerical value more than once every 3 years on the average	U.S. Environmental Protection Agency, 1986 (35)
	Examples[c] 3.5 µg/L at pH=6.5 13 µg/L at pH=7.8 43 µg/L at pH=9.0	- four-day average concentration not more than once every 3 years on the average	
	7.9 µg/L	To protect saltwater biota - four-day average concentration not to exceed the criterion more than once every 3 years on the average	
	13 µg/L	- one-hour average concentration not to exceed the criterion more than once every 3 years on the average	
Objectives[d] (Fraser River)	0.2 µg/kg 100 µg/kg (wet weight) 10 µg/kg (dry weight)	Maximum in water Maximum in fish Maximum in bottom surface sediments	B.C. Ministry of the Environment (34)
Objective	0.5 µg/L	To protect of all forms of life in receiving waters	Ontario Ministry of Environment
Guideline	0.05 µg/L	To protect aquatic life	Canadian Council of Resource and Environment Ministers (37)

a "Maximum Acceptable" is defined by Health and Welfare Canada as follows: "Drinking water that contains substances in concentrations greater than these limits is either capable of producing deleterious health effects or is aesthetically objectionable".
b Expressed as an exponential function: PCP Limit (µg/L)= exp(1.005(pH)-4.830).
c Expressed as an exponential function: PCP Limit (µg/L)= exp(1.005(pH)-5.290).
d Sum of tri-, tetra- and pentachlorophenol.

criteria necessary for protection of marine biota from any chemicals, including PCP, and the U.S. EPA criterion for marine waters is suggested for current use in Canada.

As of 1986, the British Columbia Ministry of Environment and Parks remains the only Canadian regulatory agency that has defined upper limits for PCP in biota and sediments. The objectives shown in Table 3.4 are applicable to the total of tri-, tetra-, and pentachlorophenol concentrations in bottom surface sediments and fish muscle. The limits are based on the Ministry's assessment of current "background" concentrations, and thus the Ministry's intent to discourage additional inputs to the environment.

3.4 Human Health Concerns

One safety objective of industrial usage of any chemical is to minimize worker exposure. If safeguards are not provided or not implemented, a variety of human health effects may occur dependent upon: the duration and manner of exposure; concentration of the chemical to which exposure has occurred; form of the chemical (e.g., ionic vs. nonionic); and varying metabolic sensitivities of individual workers.

On the basis of information from existing literature, Table 3.5 outlines the spectrum of human health effects that could result from various degrees of exposure to PCP (38). Overlaps of different exposure categories are noted in the table and reflect real situations, which may be due in part to variable individual sensitivities.

Many reviews have been published on the potential and known health effects which result or could result from over-exposure to PCP, including those of Williams (39), Wood et al. (40), Jones (18), the American Conference of Governmental and Industrial Hygienists (41), the International Labor Organization (42), the United Nations Environment Programme IRPTC (43), the U.S. National Institute for Occupational Safety and Health (14) and the U.S. Environmental Protection Agency (26,36). A 1987 review of health effects is provided by Health and Welfare Canada in an Agriculture Canada discussion document on pentachlorophenol (56). Although the conclusions of Health and Welfare Canada were received at the completion stages of this document and are not discussed, they are reflected in Table 3.6. Table 3.6 provides excerpts from several reviews to illustrate the potential pathological, physiological and biochemical effects that could result from overexposure to PCP.

3.4.1 Known Human Health Effects. PCP can be safely used in the workplace if suitable precautions are taken (14,44,45). If safeguards are not provided or are inadequate, short-term (acute) and long-term (chronic) health effects could develop (Tables 3.5 and 3.6).

TABLE 3.5 THE RANGE OF POSSIBLE HUMAN HEALTH EFFECTS FROM EXPOSURE TO PENTACHLOROPHENOL

Exposure Category	Relative Level of Chlorophenol in the Body*	Possible Health Effects	
		Short-term Exposure	Long-term Exposure
General Population, e.g., chlorophenol intake from environmental sources	1	None	None
Properly Protected Worker - Minimal Exposure	1 to 100	None	None
Worker Exposure with Moderate Skin Contact and/or Moderate Exposure to Vapours or Dusts	17 to 200	Irritation of skin, eyes, upper respiratory system. Possible increased metabolism.	
Worker with Significant Overexposure, e.g., frequent skin contact, exposure to high dust levels	33 to 1000	Profuse sweating, Headaches, Nausea, Weakness, Fever, Intense thirst	Dermatitis, Chloracne; Suspected damage to kidney, liver, nervous system; Weight loss
Major Accidental Overexposure, e.g., ingestion	833 to 30 000	Death from heart failure	

* The "relative level" values are based on urine monitoring data presented in Reference 38. The numbers are illustrative only and indicate the order of magnitude of chlorophenol exposure that might be experienced under varying conditions of exposure. Background levels of chlorophenol in urine for the general population vary from 5 to 40 parts per billion.

Studies of workers at wood protection and preservation facilities, have illustrated the health hazards that can result from overexposure to PCP. Where gross misuse of PCP has occurred (due either to the absence of design controls or because of unsafe work practices), a variety of marked health effects have been documented. Excessive exposure of some workers to PCP dusts during the handling of bagged PCP in

TABLE 3.6 SUMMARIES OF POTENTIAL HEALTH EFFECTS OF OVEREXPOSURE TO PENTACHLOROPHENOL

American Conference of Governmental and Industrial Hygienists (41)

* Dermal penetration has been demonstrated to be the most important pathway of PCP exposure. The compound readily penetrates the skin. Physiologic injury is mainly vascular with heart failure.
* PCP and its sodium salt are capable of inducing discomfort and local as well as systemic effects. Dusts are irritating to the eyes and nose in concentrations less than 1 mg/m^3. (Tolerance depends on individual sensitivities; irritation may occur at concentrations ranging from 0.3 to 2.4 mg/m^3).
* The 0.5 mg/m^3 Threshold Limit Value (TLV) and the short-term exposure limit (STEL) of 1.5 mg/m^3 are derived by analogy with other compounds of similar action and toxicity in addition to the available information. They are believed low enough to prevent vascular injury.

International Labor Organization (42)

* Skin irritation is likely to result from a relatively brief, single exposure to a solution containing 10% of the material. A 1% solution could cause irritation if contact is repeated. A solution containing 0.1% or less could result in adverse effects after prolonged contact.
* Fine dusts and sprays of PCP or its sodium salt cause painful irritation to the eyes and the upper respiratory tract. This is an excellent warning because the painful irritation in the nose will prevent prolonged exposure to concentrations that might produce adverse systemic effects.
* PCP has been identified as a causative agent of occupational asthma.
* Severe intoxication including fatalities have been reported from the practically uncontrolled use of PCP solutions. Intoxications have been reported among uninstructed workers at wood-immersion treatment facilities who disregarded safe-handling practices.
* Symptoms of severe systemic intoxication include loss of appetite, respiratory difficulties, anesthesia, hyperpyrexia, sweating, dyspnea, and a rapidly progressive coma.
* Good housekeeping in manufacturing plants will keep undesirable effects at a minumum.

U.S. Environmental Protection Agency (26, 36)

* Based on available and cited literature, PCP is not considered a carcinogen. The National Cancer Institute has conducted studies on the carcinogenicity of the PCP contaminants hexachlorodibenzo-p-dioxin (hexa CDD) and octachlorodibenzo-p-dioxin. Results indicate that a mixture of two isomers of hexa CDD was carcinogenic in laboratory animals by oral but not by dermal methods.
* Observed effects of PCP on test animals include embryotoxicity and fetotoxicity at doses above 5.8 mg/kg.
* One group considered a "special group at risk" comprises formulators and wood treaters. Exposure, hygiene, and industrial health practices vary from the small wood treaters to the larger companies. Health-related data in general are not available. Employees of two Hawaiian wood-treating companies have been studied for a number of years, and although exposures have resulted in blood and urine levels of 1 to 10 mg/L, adverse health effects have been minimal.

Driesbach (46)

* The lethal dose for humans (based on animal studies) is approximately 1 g PCP (based on 46 µg PCP per millilitre blood serum). Note: other studies suggest lethal doses up to 3 g (69).

Williams (39)

* In acute exposures, the toxicity of PCP itself is of the most concern (of all ingredients in technical grade PCP).
* The contaminant hexachlorodibenzo-p-dioxin, in levels present in technical grade PCP, causes chloracne in occupationally exposed workers.
* Although certain areas of the PCP toxicological profile are incomplete, it is thought that PCP can be used in industry without undue health risks to occupationally exposed individuals, based on the available literature. This statement assumes certain precautions such as worker training in the proper use of personal protection equipment and air concentrations maintained below the TLV.

Wood et al (40)

* Potential exposure to PCP exists for workers involved in the manufacture, distribution and application of this chemical. Automated processes and closed systems have significantly reduced exposure at large-scale facilities.
* At the current U.S. Occupational Health and Safety Administration standard of 0.5 mg/m^3 the body requires about one week (168 hours) to eliminate 86% of the absorption resulting from a single workday's exposure to PCP. Repeated workday exposure at this level results in a maximum steady state plasm concentration of approximately 5 ppm with no adverse effects noted. Following continued exposure at higher levels, the body's ability to excrete PCP can be overcome and toxic levels are reached.

Markel and Lucas (47)

* Nearly all the chemical substances utilized in wood preservation are highly toxic. The effects of long-term exposure to several of these substances are such that periodic medical monitoring is deemed essential.
* Prospective employees should receive a medical examination, chest x-ray, hemogram, urinalysis, and routine battery of clinical chemistries. A complete medical history should also be obtained. Persons with historic or present evidence of significant liver or kidney disease should not be employed in the treating area. Those with active acne vulgaris or a history of moderate-to-severe acne should likewise be excluded.
* On an annual basis, the medical examination, chest x-rays, hemogram, urinanalysis, and chemistries should be repeated. Particular attention should be focused on the eyes, throat, nose and skin.

International Agency for Research on Cancer (48)

* Inadequate evidence for carcinogenicity to humans or animals.
* Inadequate evidence for activity in short-term tests.

poorly ventilated areas resulted in chloracne, hypertension, eye burning, skin discoloration, and liver dysfunction (14,47). Wood et al. (40) documented two cases of industry fatalities which occurred as a result of jack-hammering of PCP blocks and manual emptying of bags in small, poorly ventilated rooms. Other circumstances, not typical of wood preservation facilities, resulting in fatalities associated with chlorophenols have been reported in the literature (49,50). Nonetheless, the circumstances illustrate the potentially extreme effect of prolonged and direct contact of feet, hands and/or body with chlorophenol solutions.

A review of the literature suggests the constant need for identifying and implementing precautionary and evaluative procedures for workers at each individual facility (51). The most serious workplace concern expressed during the 1984 Environment Canada study (1) was with regard to worker exposure to PCP vapours. Vapours released from open tanks during the hot oil treatment cycle could be of concern to worker health, particularly if breathing protection and careful operating practices are not in place. Previous studies (references 13 and 16) suggest that workers at some thermal and "open vat" facilities can be more exposed to PCP than workers at pressure facilities. For example, both studies indicated that workers at thermal facilities had higher concentrations of PCP in urine than workers at pressure facilities (13,16).

In addition to potential health effects attributed directly to the PCP molecule, the effects of certain trace impurities must also be considered. Chlorinated dibenzo-p-dioxins (dioxins) and chlorinated dibenzo-p-furans (furans) are found in technical grade PCP (18,52,53). Chlorinated "dioxins" and "furans" are actually families of compounds consisting of 75 different forms of dioxins and 135 possible forms of furans. The toxicity imparted to chlorophenols by these impurities depends strongly on the concentration and identity of the specific forms that are present.

Although the nature and significance of various impurities in commercial chlorophenols are not well understood, they are currently under intensive investigation. Technical grade PCP (as of 1986) contains chlorinated dioxins or furans at milligram per kilogram (ppm) levels (51,52,53). The most potent dioxin, 2,3,7,8-tetrachlorodibenzodioxin, has not been detected in commercial PCP. The most common form is the relatively innocuous octachlorodibenzodioxin, with lesser quantities of the heptachloro- and hexachlorodioxins. Williams (39) has suggested that hexachlorodibenzo-p-dioxin may be at sufficient concentrations to cause chloracne in occupationally exposed workers. A review by Baker and Matheson (53) cautioned that the isomers, although much less toxic than the tetrachlorodioxin, warrant caution and underscore the need for appropriate

measures in handling PCP. It is clear that following good safety practices for handling PCP also reduces worker exposure to any toxic impurities that may be present.

3.4.2 Special Sensitivity. Natural sensitivity to the toxic effects of PCP exposure varies. Some workers may be especially sensitive, including individuals with pre-existing skin problems, a history of liver or kidney disease, or a history of metabolic disorders caused by conditions such as diabetes or thyroid disease (47,54). Prior to employment, workers should be informed of such sensitivities. The information should not be used to discriminate workers from employment but to assure that proper precautions are applied. For reasons of prudence it is suggested that pregnant women not be exposed to excessive levels of PCP.

3.5 Conclusions

There is a large database on the potential effects of PCP to the environment and to human health. The database has been intensively reviewed by regulatory bodies and organizations such as the International Labor Organization, the American Conference of Governmental Industrial Hygienists (57), the United Nations Environmental Programme, Environment Canada (55), the International Joint Commission and the United States Environmental Protection Agency. More recently an Agriculture Canada discussion document on PCP also provided a review of the database (56). These reviews have promoted an awareness of the precautions that are necessary in the handling and use of PCP.

This document is in agreement with the conclusions of agencies such as the International Labor Organization (42) and reviewers such as Williams (39) that PCP can be used in industry without undue health risks to occupationally exposed workers, provided that certain precautions are taken to assure that workers are adequately trained in the proper use of protective equipment and in hygiene practices and that facilities are designed to minimize air concentrations and skin exposure. Similarly, as has been demonstrated at many existing facilities, protective measures can be installed to adequately protect the environment from PCP releases.

4 PERSONNEL PROTECTION

4.1 Precautions and First Aid

The potential hazards of exposure to chlorophenols or to solutions of chlorophenols and their salts include immediate and long-term toxic effects from ingestion, skin contact or inhalation of vapours or dusts (Tables 3.5 and 3.6). It is emphasized that these potential hazards can be adequately controlled by proper protective measures. The severity and speed of damage to tissue and probability of health effects following contact with chlorophenols are highest with concentrated solutions. Both factors diminish as the solution is diluted. The general rule is: The higher the concentration of PCP to which a worker is exposed, the greater the need for protective measures and immediate response if contact occurs. At a thermal wood preservation facility, solid PCP would constitute the highest concentration, followed by (in order of diminishing concentration) 3-6% work solution $\geq$ tank sludges $\gg$ storage area runoff waters. If there is any doubt as to the concentration, the response should be the same as for the most concentrated form (e.g., unknown oil solutions should be treated as 3-6% concentrates).

Table 4.1 describes first aid procedures to be used for PCP exposures (46, 55). In all cases it is important that first aid personnel maintain regular contact with PCP suppliers and/or industrial medical advisors for information on up-to-date response measures. Table 4.2 outlines specific objectives for an overall worker protection program in a PCP wood preservation facility. Means to achieve the objectives are presented in the table, but the recommendations may not be the sole options available to attain the objectives. Alternative approaches may be equally effective or more suitable for site-specific conditions. When programs are developed for a particular facility, the specific recommendations provided may be modified if it can be demonstrated that an alternative approach, more suitable to plant-specific conditions, would be equally effective in attaining the desired objective.

With the use of PCP, it is particularly important that protection be provided for all potential types of exposure -- eye contact, skin contact, and inhalation. Many work situations require protection against more than one type of exposure, e.g., when chlorophenol dusts, aerosols or vapours are produced. For example, the use of nose-mouth respirators which do not cover the eyes and facial skin around eyes may lead to a false sense of security (56). Full face shields or full face cartridge respirators are

TABLE 4.1 FIRST AID FOR PENTACHLOROPHENOL EXPOSURE*

Exposure	First Action	Second Action
Eye Contact	• Immediately flush eyes with flowing water, occasionally lifting the upper and lower lids. • Flush eyes for at least 15 minutes.	• Use boric acid solution and cortisone ophthalmic drops. • Get medical attention.
Skin Contact	• Immediately remove soaked clothing or articles in contact with the skin. • Immediately wash contaminated skin thoroughly with soap or mild detergent and water.	• Get prompt medical attention if the skin becomes inflamed (redness, itch or pain).
Inhalation	• Immediately remove the exposed person to fresh air. (Coughing and sneezing occur almost immediately after excessive inhalation of chlorophenols.)	• Apply artificial respiration if breathing has stopped. • Keep the affected person warm and quiet. • Get immediate medical attention.
Ingestion	• For PCP solids: If conscious, have the victim immediately drink large quantities of water and induce vomiting. Regularly consult with competent medical advisors for updated recommended first and second actions for PCP in oil.	• Call the Poison Control Centre or an industrial physician for subsequent advice.
Chronic Symptoms Requiring Medical Referral	• Dermatitis, headaches and nausea. • Hyperthermia, fever, sweating. • Chloracne.	

* Potential contact exposure to pentachlorophenol in thermal treating facilities includes exposure to PCP solids, solutions of PCP in oil (treating solutions) and sludges, and contaminated aqueous solutions. Inhalation exposure can occur from vapours, aerosols or dusts.

TABLE 4.2 SAFETY PRECAUTIONS FOR PERSONNEL WORKING WITH PENTACHLOROPHENOL SOLUTIONS

General Precautions	
Objective	Recommendations
Assure that workers are familiar with all aspects of PCP usage	• Provide documentation and training to educate workers about the chemical properties, hazards of exposure, and emergency procedures associated with PCP use. • Implement preventative measures to minimize ingestion, inhalation, and skin or eye contact with PCP, PCP solutions and contaminated waters.
Assure that first aid can be applied when required	• Install and regularly check emergency eyewashes and showers. • Provide all required first aid equipment for first response as indicated in Table 4.1. • Ensure that first aid is always available by qualified (trained) personnel. (Trained personnel may include supervisors and managers.) • Ensure familarity of first aid personnel with updated emergency response procedures. • Identify medical contacts who are readily available during all working hours.
Personal Hygiene	
Encourage personal hygiene practices which minimize potential exposure to PCP	• Do not carry, store or consume food or drink in working areas (e.g., areas where PCP and/or PCP solutions are stored or used, or where freshly treated wood is stored). • Do not carry or smoke cigarettes in working areas. • Wash hands thoroughly before leaving working areas and before eating, drinking, smoking, or using the toilet facilities. • Do not expose cuts or abrasions to PCP solutions. • Wash skin immediately if contact with PCP occurs. • Get immediate first aid (Table 4.1) if skin or eyes contact PCP or PCP/oil solutions. Even small contact exposures should receive immediate cleansing and treatment. • Change outer clothing immediately if splashed with PCP solutions. Change clothing daily if any incidental contact with the treatment chemical occurs. Wash contaminated clothing separately from other clothing. • Wear impermeable footwear in all working areas. PCP/oil solutions may penetrate shoes and leather.

TABLE 4.2 SAFETY PRECAUTIONS FOR PERSONNEL WORKING WITH PENTACHLOROPHENOL SOLUTIONS (Cont'd)

Specific Precautions During PCP Treatment	
Objective: To outline safe workplace practices for each activity during the treatment process.	
Activity	Recommendations
Unloading PCP solids	• Wear protective apparel including chemical goggles or face shields, impermeable gauntlets, coveralls, impermeable aprons, and impermeable shoes or boots. (Resistance rating of materials: Excellent - Viton, Neoprene, Butyl Rubber; Good - Nitrile, Polyvinyl chloride (PVC); Fair - Polyvinyl alcohol, Polyethylene) • Do not wear contact lenses. • Work in well ventilated areas. • Approved respirators should be readily available. Wear respirators in accordance whenever exposure to dust can occur. • Provide an emergency eyewash and shower in the immediate unloading or handling areas. • Provide adequate equipment for safe, controlled handling of blocks, bags and/or bulk PCP prills/flakes and as appropriate for the specific facility. • Do not drop blocks or PCP containers. • Immediately vacuum PCP chips or spilled solids (vacuums should have effectively filtered exhausts).
Preparing PCP work solutions	• Work in a well-ventilated area. • Provide an emergency eyewash and shower in the immediate area. • Wear full face protection, organic solvent-impermeable gauntlets, coveralls, aprons and shoes or boots for all operations involving handling of PCP solids. • In addition, wear an approved full facepiece respirator when handling PCP prills, granules or flakes, or whenever dust conditions occur. Respirator cartridges must be NIOSH rated for protection from "pesticides and organic vapors and dusts". • Thoroughly vacuum PCP dust and solids from the work area following solution preparation. • Dispose of empty PCP containers, empty bags, wraps and PCP-contaminated debris according to Table 8.1. • Thoroughly clean protective equipment after use.
Sampling Procedures	• Wear eye protection and gloves impermeable to organic solvents when sampling PCP solutions. • Wear impermeable gauntlets when taking borings from freshly-treated wood. • Clean gauntlets, and goggles as soon possible after completing sampling. • Clean the outside of sample containers immediately after sampling solutions. • Wash hands thoroughly after all sampling operations.
Cleaning treatment or storage tanks	• Follow all standard precautions for vessel entry (as per provincial health and safety regulations). • Flush vessels as required to establish safe entry conditions, or use an approved self-contained breathing apparatus prior to entry. • Wear NIOSH approved respirators (or breathing apparatus as above), organic solvent impermeable gauntlets, outer clothing and boots during all vessel entries. • Always have a standby attendant present and provision for continuous outside communications. • Collect and store contaminated waste material in sealed and labeled drums. • Wash all protective equipment immediately after use. • Shower after completion of clean-up tasks.

TABLE 4.2 SAFETY PRECAUTIONS FOR PERSONNEL WORKING WITH PENTACHLOROPHENOL SOLUTIONS (Cont'd)

Specific Precautions During PCP Treatment	
Activity	Recommendations
Removing treated charges from tanks	• Wear eye protection and organic solvent impermeable gauntlets and coveralls or apron if manual handling of slings for charge removal is required. • Avoid breathing preservative mists. Wear an approved respirator if airborne concentrations are unknown, or at or above TLVs*.
Handling treated lumber	• Wear impermeable** gloves, apron and boots if handling treated wood manually. • Wear a respirator if treated wood is handled in enclosed areas (e.g., boxcars). • Change coveralls daily if soiled.
Handling and maintaining contaminated equipment	• Thoroughly steam-clean or flush contaminated equipment with solvent (e.g., Varsol or equivalent) prior to handling. (Contain all solvent washings). • Change coveralls daily. • Wear impermeable** apron, glove and boots.
Welding	Welding can produce toxic fumes. In addition to the precautions for handling and maintaining contaminated equipment: • Obtain the specific approval of the plant supervisor before welding. • Block or disconnect lines from tanks before initiating welding operations. • Completely drain and thoroughly rinse tanks or lines prior to welding operations. • Ensure that equipment is completely dry and free from cleaning solvent residues. • Wear a respirator or provide effective, local exhaust ventilation during welding to prevent potential exposure to toxic fumes. • Assure good general ventilation of the work area. • Comply with all additional provincial workplace safety requirements (Appendix A).

* An initial workplace monitoring program as suggested in Table 8.3 will have determined the need for respirator use. The results of the program are assumed to be indicative of conditions in subsequent facility operations, unless procedural or design changes have occurred.

** Heavy-duty, lined neoprene or polyvinyl chloride.

recommended. In selecting protective gloves, both the material and the make have to be taken into account. Nitrile rubber and PVC appear to be suitable materials (58, 59).

4.2 Regulatory Controls

Specific provincial regulatory limits for worker protection are found in Appendix A of this document. Most regulatory criteria established by worker protection agencies are based on "Threshold Limit Values (TLVs)" and "Biological Exposure Indices", as recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). Table 4.3 reviews the ACGIH recommended limits for PCP and provides recommendations designed to specifically define acceptable levels of chlorophenol exposure in the wood preservation workplace.

Skin and eye contact. The ACGIH has recommended a threshold limit value - time-weighted average (TLV-TWA) for PCP, which represents a time-weighted average concentration "for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect." The recommended TLV-TWA value for PCP is 0.5 mg/m^3, and is followed by the designation "skin" which refers to "the potential contribution to the overall exposure by the cutaneous route including mucous membranes and eyes, either by airborne, or more particularly, by direct contact with the substance" (57). The 1985-86 ACGIH recommendations include a threshold limit value - short-term exposure limit (TLV-STEL) value of 1.5 mg PCP/m^3, which represents the 15 minute time-weighted average exposure which should not be exceeded at any time during a work day. However the 1985-86 ACGIH document (57) has served notice that the TLV-STEL value for PCP will be deleted, "unless new evidence comes to light that questions the appropriateness of the deletion".

The ACGIH TLV-TWA's for chemicals are defined with the following provisos:

- "The limits are intended for use in the practice of industrial hygiene as guidelines for good practices or recommendations in the control of potential health hazards and for no other use" (i.e., not for proof or disproof of the cause of an existing disease or physical condition).
- "The limits are not fine lines between safe and dangerous concentrations".
- "In spite of the fact that serious injury is not believed likely as a result of exposure to the Threshold Limit concentrations, the best practice is to maintain concentrations of all atmospheric contaminants as low as is practical."

TABLE 4.3 LEVELS OF CONCERN FOR PENTACHLOROPHENOL EXPOSURE IN THE WORKPLACE

Route of Entry	Basis for Recommendation	Recommendations/Comments
Skin and eye contact	PCP is a skin irritant and can be absorbed through the skin.	• Protective measures should be used by workers in contact with PCP solids or PCP/oil solutions (Table 4.2). • Avoid direct contact of skin and eyes with PCP solids or PCP/oil solutions. • Sensitive individuals (as defined in Section 3.4.2) should take special care to avoid exposure. Comment: Current material safety data sheets should always be readily available to workers.
Inhalation	ACGIH Threshold Limit Value 8-hour Time Weighted Average (TLV - TWA): PCP: 0.5 mg/m^3 air (Potential contributions to overall exposure can occur through the cutaneous route including mucous membranes and eyes, either by airborne, or more particularly, by direct contact with the substance.)	• Full face protection and good ventilation should be used during chemical unloading, and mixing operations. • Provide respiratory protection, eye protection and good ventilation: - during manual handling of PCP prills or flakes - when welding contaminated equipment - during any activity which might generate PCP vapours - when PCP mist or dust is present. • Self-contained breating apparatus should be used for fire-fighting activities where PCP is present. Comment: The permissible concentration of PCP refers to vapours; PCP could also occur in air as an aerosol or in contaminated dust.
Ingestion	The reported lethal dose of PCP for adults ranges is approximately 1 to 3 grams (46, 58).	Prevent the ingestion of any quantity of PCP.

- "When two or more hazardous substances, which act upon the same organ system, are present, their combined effect, rather than that of either individually, should be given primary consideration."

Recently the ACGIH suggested that TLV workplace evaluations be augmented by "biological exposure indices (which) may be useful as a guide to safe exposure" (41).

In practice, a wide range of dermal exposures to PCP can be encountered in the wood treatment workplace, i.e., from pure PCP solids to waters containing a few parts per million PCP. Dermal penetration is a significant route of PCP uptake and penetration is enhanced if exposure to PCP-oil solutions occurs (47). A minimal level of protection and hygiene, e.g., impermeable gloves and regular clothing changes, should be required for all facility workers who have any potential for dermal exposure to PCP, oil and aqueous solutions of PCP, or freshly treated wood. The level of protection should increase with increasing potential for exposure to PCP.

Inhalation. The ACGIH TLV-TWA values for PCP discussed previously for "skin and eye contact" would also be applicable to maximum allowable values for inhalation. The ACGIH in its rationale for TLV-TWA's states that PCP "dusts are particularly irritating to the eyes and nose in concentrations greater than 1 mg/m^3. Some irritation may occur at 0.3 mg/m^3. Seasoned workers can tolerate up to 2.4 mg/m^3 (41)."

A review of the literature indicates that many of the documented industrial health incidents involving PCP have occurred as a result of dumping bagged PCP flakes in poorly ventilated areas (14,40,47). Other exposures to dusts may occur during activities such as jack-hammering of PCP blocks (40) or during cleanup of spilled PCP solids. Adequate designs and operational procedures must be assured to minimize worker exposure to PCP dusts, i.e., adequate local ventilation, use of respiratory equipment and use of wet or vacuum methods for cleaning of spilled PCP solids. Other potential sources of inhaled PCP include: vapours in the vicinity of charge removal areas and in the vicinity of freshly treated wood; and aerosols at improperly maintained facilities (e.g., from leaking seals) or at inadequately designed facilities (e.g., from vacuum pump discharges to work area).

Ingestion. Oral intake of PCP must be avoided. Ingestion of PCP or PCP-containing liquids is unlikely if workers follow elementary rules of good hygiene. Acceptable limits of ingestion are not prescribed by regulation since there is no valid reason for any such intake to occur. The single dose level of PCP known to result in fatality is in the order of one to three grams (46, 58).

4.3 Biological Monitoring of Exposed Workers

Routine biological monitoring of exposed workers can be achieved using established procedures for the determination of chlorophenols in blood and/or urine (13). Biological monitoring is a useful tool for evaluating the long-term effectiveness of protective measures in a given situation. It is important that the monitoring programs be carried out and interpreted by appropriately qualified occupational hygienists or occupational physicians. If there is concern for confidentiality and/or sample handling procedures, it is suggested that these concerns be addressed and resolved by a joint management-worker committee.

5 SITE SELECTION

5.1 Purpose

Preliminary assessment of an industrial site involves an evaluation of technical site characteristics (e.g., hydrogeology, topography and soils) and socio-geographic factors (e.g., land use and availability, and proximity to transportation routes). This section highlights technical features of wood preservation facility sites that contribute to the control of any potential PCP releases.

In many cases, natural site characteristics may impose constraints on technical features of a PCP wood preservation facility. Early recognition of less desirable site characteristics will enable the development of a compensating facility design and facilitate site approval.

Criteria for site assessment discussed in this section may also indicate the aspects of existing treatment plant facilities that need to be modified or changed to assure protection of the environment and worker health.

5.2 Assessment Factors

Use of PCP at a plant site introduces the potential for contamination of groundwaters and surface waters. The extent of potential contamination by released PCP is, in turn, dependent on the chemical, physical and biological properties of PCP, plant design and operating practices as well as site-specific characteristics including: soil type, geology, hydrology, climate, topography and drainage.

This section describes environmentally important site characteristics and how these characteristics can affect the eventual impact of a chemical release. These factors are important in designing features of a wood preservation plant that will:

a) minimize the possibility of off-site contamination via groundwater and surface waters;
b) minimize chronic on-site contamination to protect worker health; and
c) facilitate decommissioning of the plant in the event of partial or complete closure.

The assessment factors rely upon readily available information. Table 5.1 lists the site features that must be considered in an environmental impact assessment.

5.2.1 Regional Geology. Geologic information about many areas of Canada may be obtained from federal and provincial surveys. Information that should be obtained includes:

- Texture of unconsolidated material - Fine-grained material is more likely to retain chemical contaminants than coarse material.
- Depth to bedrock - Shallow soils imply a limited ability to retain spilled chemicals.
- Aquifer recharge and discharge zones - Potential for hydraulic connections to regional groundwater and sensitive surface waterbodies should be considered.
- Discontinuities such as faults, fissures, joints, fractures - Discontinuities may cause "short-circuiting" of a contaminant plume.

5.2.2 Soils. Soil properties should be assessed to evaluate the potential for leaching and retention of treatment chemical constituents. Physical characteristics of soil to consider include depth, permeability, texture, water holding capacity, shrink-swell potential; chemical characteristics to consider include anion exchange capacity (AEC), organic carbon content, and iron and aluminum oxide content (55). Soils with higher amounts of organic carbon will have higher capacities for sorption of neutral organic compounds. Soils with high anion exchange capacities will provide greater retention of dissociated chlorophenols. Soil depth and soil types are routinely indicated on soil maps (and often on geology maps). Although the available maps may not indicate the exact soil composition of a small site (e.g., 2 hectares), they can be used for preliminary assessment purposes.

5.2.3 Geotechnical Description (including subsurface hydrology and water table data). Published maps and reports on regional geology and soils are adequate references with which to infer subsurface hydrogeology at the preliminary site assessment stage. However, site-specific hydrologic data will be required if one or more of the following conditions is identified during preconstruction assessment:

a) The site is located over a shallow unconfined aquifer.
b) The site is located over an aquifer used for a potable or irrigation water supply.
c) The aquifer has hydrologic connections with other aquifers in the area and/or regional groundwater flow patterns.

The additional information required will have to be defined in consultation with the appropriate regulatory agency.

5.2.4 Topography. Topographical information is easily obtained from published government maps. In general, steep sites should be avoided due to runoff problems and erosion. However, topography is a site selection parameter that can be modified by

facility design. Slope gradients between 1-10% should present few problems. Upland flat and terraced landforms are desirable locations for treatment facilities. Floodplains are acceptable if they lie above the 100-year flood level; otherwise special design provisions must be implemented.

5.2.5 Climate. Climatic variables such as precipitation (form, historical 1-hour and 24-hour maxima, and annual total amount), temperature regime and wind patterns influence chemical loss during storage of treated wood, potential for degradation of any released PCP and leaching in the subsurface. Climatic variables can also influence conditioning requirements for wood prior to PCP application and can affect worker exposure to emissions. Information on such climatic variables is generally available from Environment Canada. However, definitive criteria are difficult to establish for climatic influences. For example, the amount of precipitation will influence leaching potential but this parameter can be alleviated by selection of sites with soils of low permeability and/or by compensating design features at the facility.

5.2.6 Proximity to Sensitive Uses. Sites located adjacent to waterbodies (e.g., lakes, rivers, marine waters) or above aquifers used for drinking or irrigation water supplies, food manufacturing plants and beverage processing plants, should be considered cautiously by the wood preservation industry. If such a site is selected, exceptional design requirements and operational and monitoring procedures will be required. Desirable minimum distances between PCP facilities and sensitive waterbodies depend upon previously discussed factors such as soil type, regional geology, topography and climate. If a selected site is adjacent to waterbodies used by migratory fish, then the intended plans will have to be reviewed by both the Environment Canada, and Fisheries and Oceans Canada.

5.3 Selection Procedures

After compiling the data for potential sites, the developer of a facility is faced with a decision-making process for site selection. The process integrates environmental protection with economic considerations. On the basis of economic factors alone, a less environmentally acceptable site might be most desirable. However, since the less acceptable environmental features in the design and operation of the wood preservation facility will add to the cost of adapting the facility to the site, environmental protection must be interpreted as a real cost of locating a facility at such a site.

All factors previously described should be considered. Techniques that may be used to select a site on the basis of environmental acceptability include criteria ranking, matrices, decision trees, or mathematical modelling. Since assessment techniques among regulatory agencies may vary considerably, local and provincial regulatory agencies must be consulted (as well as federal agencies where necessary).

Table 5.1 provides examples of site characteristics requiring very little environmental mitigation as well as those requiring significant environmental mitigation. Deviations from the most desirable characteristics suggest varying degrees of mitigating design and operational measures.

- Slight mitigating design/operational measures are necessary for site features that are well suited to the location of a treatment facility. The site will require only low cost maintenance and monitoring to assure environmental protection.

TABLE 5.1 SITE FEATURES AFFECTING THE DESIGN OF A PENTACHLOROPHENOL TREATMENT FACILITY

	Suggested Degree of Mitigating Design/Operational Measures	
Site Features	Slight	Severe
Soil Texture	loam, silt loam, silty clay loam, clay loam, sandy loam	gravel
Permeability (cm/h)	<0.5	>50
Topography (% slope)	0-9	>30
Soil Depth to Bedrock (cm)	>200	<60
Depth to Groundwater (cm)	>200	<60
Flooding	None	Frequent (>once/20 yr)
Drainage	Slow	Very rapid
Distance to surface waterbody (lake or river)	Depends on interaction with other site features (e.g., permeability of soil)	Directly adjacent

- Moderate mitigating design/operational measures present more of a problem, but in general sites requiring such measures are acceptable.
- Severe mitigating design/operational measures such as special innovative designs may partially overcome the constraints of a marginally suitable site. Design costs are likely to be high. Extensive monitoring efforts will be required adding to the cost of locating a treatment facility at such a site.
- Very severe mitigating operational/design measures pose such a threat to environmental protection that the site may be economically impractical.

Site features and the degrees of mitigating design/operational measures shown in Table 5.1 are based on siting criteria suggested by various investigators (60, 61).

6 DESIGN

This section suggests approaches for the design of thermal pentachlorophenol wood preservation facilities in order to protect workers and the environment from harmful exposure to PCP*. The recommendations are based on "best practices" currently in use. The design aspects are intended to achieve the following general objectives:

a) to prevent or reduce direct contact of personnel with PCP;
b) to reduce releases of PCP to the environment to the greatest degree possible by providing secure containment and control; and
c) to enable prompt response and effective corrective measures to assure worker safety and environmental protection in the case of abnormal events (e.g., tank rupture).

Means of achieving the above design objectives at PCP wood preservation facilities are presented in Tables 6.1 to 6.6. The recommended design features in these tables may not be the sole options available to attain the stated objectives. Alternative approaches may exist which would be equally effective or more suitable to site-specific conditions. If a more suitable alternative approach can be demonstrated to be equally effective in achieving the desired objective, an appropriate design feature that has not been included in the recommendations could be used at a specific facility.

Figure 6.1 presents an overview of the subject areas covered by the design recommendations in Tables 6.1 to 6.6. The figure is based on the handling and use of PCP at wood preservation facilities, and is cross-referenced to indicate the appropriate table for each process step. It is intended that all new wood preservation facilities be designed to achieve the specific objectives listed in Tables 6.1 to 6.6.

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* Use of alternative chemicals would require a review of the recommendations, but the objectives would remain the same.

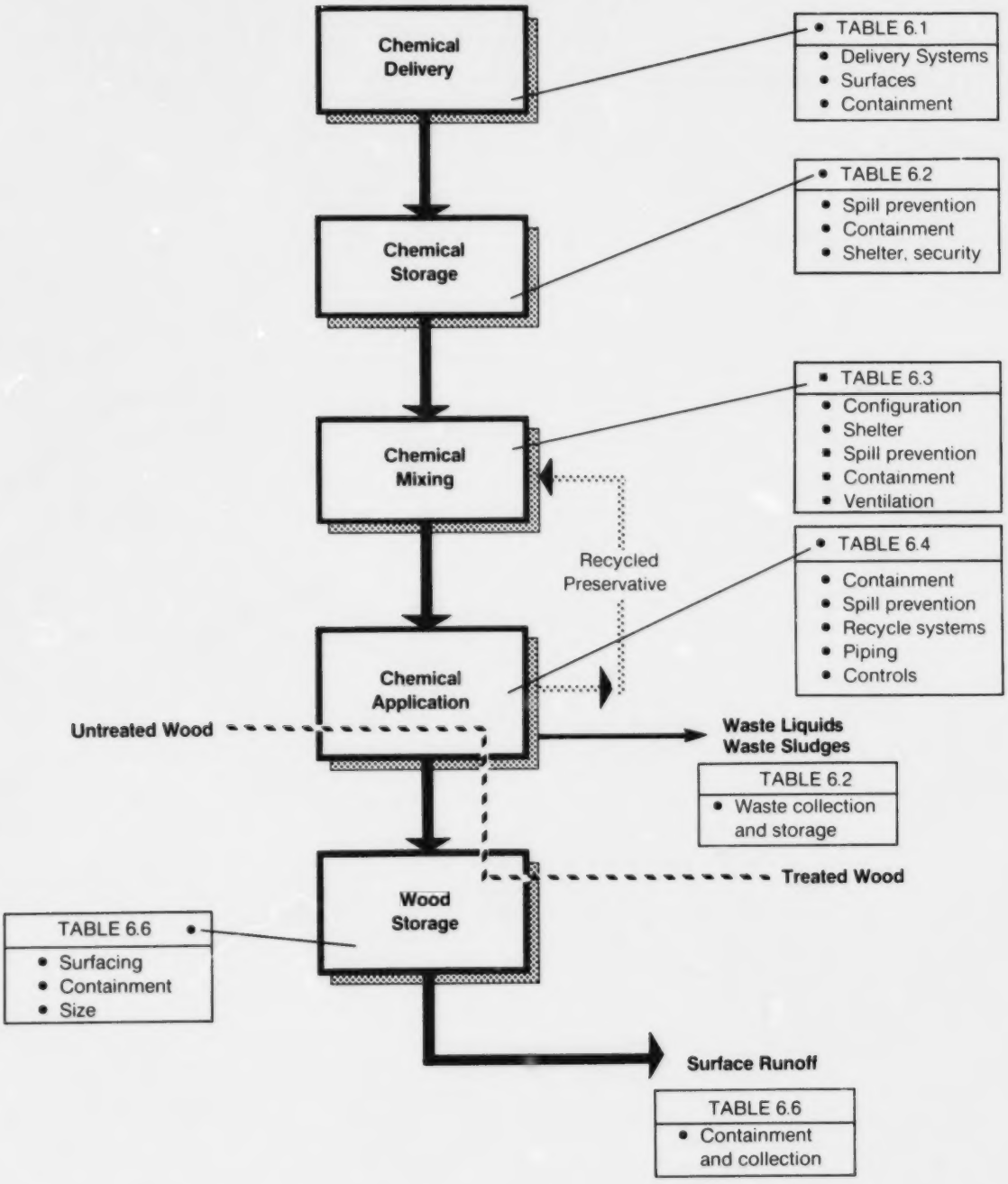

FIGURE 6.1 OVERVIEW OF DESIGN RECOMMENDATIONS FOR PCP THERMAL TREATMENT PLANTS

TABLE 6.1 RECOMMENDED DESIGN FEATURES FOR CHEMICAL DELIVERY AREAS

Delivery Format	Design Feature	Recommendation
Bulk Liquid ° Petroleum oil (CSA 080-201-83) (Delivered by Truck or Rail Tanker)	**Design Objective:**	To provide an off-loading area that enhances spill prevention and containment, and complies with Section 4 of the National Fire Code of Canada (NFCC).
	Off-loading Pad	• Provide a graded loading site or sloped floor (preferably a impervious pad) to divert spills, or provide noncombustible sills, curbs or dikes; drain to a containment area in accordance with NFCC Sections 4.1.6.1 and 4.1.6.2. • Design to prevent settling or cracking of the pad.
	Surfaces	• Seal or smooth surfaces to enhance cleanability.
	Joints	• Provide liquid tight joints (if applicable).
	Drip Control	• Design install and maintain system to prevent leakage and spillage as per NFCC 4.6.6. • Provide for wash down of minor drips or spills with recovery of wash water (or infiltrating precipitation) for treatment.
	Access	• Attempt to locate off-loading area away from high yard traffic routes. • Restrict access during delivery.
	Delivery System Piping	• Install piping and piping systems in accordance with specifications outlined in Section 4.4 of the NFCC, i.e., materials, corrosion protection, identification, joints, location and arrangement of pipes, valves, heating, methods of transfer and operating procedures. • Install permanent delivery systems with rigid, accessible and visible delivery lines (lines should not be buried). • Protect delivery systems if there is potential for vehicular impact or physical damage (NFCC 4.4.7.1(1), 4.4.7.2(1), 4.11.7.1). • Provide mechanically secure connections between the tanker and delivery hookup point. • Clearly identify all delivery lines (NFCC 4.4.4). • Use top delivery to bulk storage tanks.
	Backflow Prevention	• Install backflow preventors on delivery lines (NFCC 4.4.10.8)

TABLE 6.1 RECOMMENDED DESIGN FEATURES FOR CHEMICAL DELIVERY AREAS (Cont'd)

Delivery Format	Design Feature	Recommendation
Bulk Liquid (cont'd) ° Petroleum oil (CSA 080-201-83)	**Security**	• Install locking valves on delivery lines; restrict access.
	Overflow Prevention	• Provide maximum visibility of the delivery system from the point of off-loading. • If visibility is limited, use audible alarms to detect tank overflow during delivery.
	Static Protection	• Provide acceptable provisions for electric bonding as per NFCC 4.6.6.5 o 4.6.6.8, and 4.11.6.
	Emergency Response	• Provide accessible storage for spill response equipment, absorbant and personnel protection equipment. • Install a phone or manual alarm switch near the off-loading area.
PCP ° Solid blocks ° Bagged flakes or granules	**Design Objective:** To provide an off-loading area that promotes spill prevention and provides containment for and facilitates cleanup of spilled material.	
	Off-loading Area/Shelter	• Provide a dry, paved off-loading area with protection from the weather, preferably near the storage area.
	Containment	• Provide for containment of the worst-event spill of PCP solids (e.g., from several burst bags of a dropped pallet load).
	Surfaces	• Provide a surface that facilitates the cleanup of spilled material.
	Container Handling	• Design for safe, convenient unloading and transfer of materials as delivered.
	Area Cleanup	• Provide a vacuum cleaner system (with filtered exhaust) for cleanup of solids spilled unloading and transfer operations.

TABLE 6.2 RECOMMENDED DESIGN FEATURES FOR CHEMICAL STORAGE AREAS

Storage Format	Design Feature	Recommendation
Bulk Liquids ° Petroleum oil (CSA 080-021-83) ° PCP/oil working solutions	**Design Objectives:**	• To provide positive spill prevention features. • To conform with Section 4.3 of the NFCC, where applicable.
	Tanks	• Engineer materials of construction and dimensions in accordance with ASME, CAN and API standards as defined in Section 4.3.1 of the NFCC. • Provide tanks in sound physical condition, with no rust or serious physical damage. • Mount tanks on containment pad surfaces within a dyked area (subsurface storage tanks are strongly discouraged). • Mount tanks in stable position and anchor securely (NFCC 4.3.3). • Locate tanks in accordance with 4.3.2 of NFCC (i.e., minimum distances from buildings and other tanks). • Evaluate means of controlling contaminated surface waters (e.g., roofing of tanks, runoff water treatment). • Test for leakage prior to backfilling as per NFCC 4.3.16. • Provide means for detecting leaks in insulated tanks (e.g., identify inspection points, undertake regular leakage tests). • Vent interior tanks to the exterior (never vent to the workplace); protect vents against release of entrained liquids or overflow (e.g., provide direct overflow piping to sumps or containment areas). • Provide grounding for tanks as per 4.6.6 of NFCC. • Provide vent piping for vapour control as per 4.3.4 and 4.3.5 of NFCC.
	Spill Containment	• Install, impervious, structurally sound floors. • Provide structurally sound and impermeable dykes as per 4.3.4.7 of NFCC. • Provide dyked containment volume equivalent to 150% of the largest storage tank or vessel within the dyked area or equivalent to 100% plus 6-inch additional containing wall for single tanks in isolated containment. • Engineer containment for long-term integrity (leak-proof for infiltration and exfiltration). • Consider providing means for detecting subsurface leakage from containment systems (where warranted by site-specific conditions; e.g. where the site overlays sensitive groundwater systems). • Provide for directing all spills, washes and infiltrating water to tankage as per 4.1.6.2 and 4.3.7.9 of NFCC. (Contaminated liquids must be treated to applicable limit before discharge.)

TABLE 6.2 RECOMMENDED DESIGN FEATURES FOR CHEMICAL STORAGE AREAS (Cont'd)

Storage Format	Design Feature	Recommendation
Bulk Liquids (cont'd) • Petroleum oil (CSA 080-301-83) • PCP/oil working solutions	**Spill Containment** (cont'd)	• Provide effective capability for transferring spilled liquids from containment areas to secure storage for cleanup. • Provide surface drainage to prevent pooling of minor spills and washdowns as per 4.3.7.9 of NFCC. • Design to minimize tracking of fluids from containment surfaces.
	Piping and Valves	• Design according to applicable codes (e.g., Sections 4.4 and 4.6.6 of NFCC). • Use rigid, permanent piping throughout. • Provide visible, accessible piping with a simple layout (to facilitate early leak detection and easy repair). • Maximize the use of above floor piping and/or open containment channels for subgrade piping (avoid use of buried piping). • Properly engineer piping systems for intended use and materials. • Identify piping systems and valves (e.g., by labelling and/or color coding). • Provide mechanical impact protection for vulnerable exposed piping. • Provide freezing protection for piping (as required, and as per 4.4.9 of NFCC if heat is applied).
	Drip Containment	• Provide local collection/containment (isolated from larger containment areas) at drip points (e.g., under pumps, valves, flanges).
	Backflow Prevention	• Design to protect against inadvertant transfers to/ from interconnected tanks.
	Location	• The preferred location for oil tankage (all solutions) is in an exterior centralized tank farm area which is arranged in accordance with Subsection 4.3.2 of the NFCC.
	Security	• Provide security precautions to prevent vandalism or access to tanks by unauthorized persons (4.6.2.5 of the NFCC requires a firmly anchored fence surrounding bulk storage tanks if their aggregate capacity exceeds 564 000 L).

TABLE 6.2 RECOMMENDED DESIGN FEATURES FOR CHEMICAL STORAGE AREAS (Cont'd)

Storage Format	Design Feature	Recommendation
Bulk Liquids (cont'd) ° Petroleum oil (CSA 080-201-83) ° PCP/oil working solutions	**Spill Prevention/ Detection**	• Install reliable, accurate level indicators on all tanks. • Provide mechanical impact protection on glass sight gauges (provide means to stop and contain releases from broken gauge tubes). • Install shut-off valves on all rupturable lines and tank gauges. • Install permanent overflow piping from tanks directly to a sump or containment area. • Install devices to prevent overflow from tanks as per A-4.3.14.4 of NFCC, preferrably reliable, independent high level alarms on tanks (i.e., audible alarm). • Interlock high-level alarms to tank feed pumps (automatic shut-off). • At sites with inadequate containment areas (e.g., in terms of volume, lack of pavement) installation of 24-hour monitoring alarms (with remote) is suggested for immediate detection of tank or pipe rupture. • Install means of emergency communication (e.g., telephone, walkie talkie, etc.) manual alarm buttons (call for help) at potential major spill points.
	Emergency Response	• Provide accessible storage for spill response equipment, absorbants and personnel protection equipment. • Install a phone and manual alarm switch near the storage area.
PCP ° Solid blocks ° Bagged flakes or granules	**Design Objective:** To provide sheltered, secure, fire-protected storage of PCP solids.	
	Location	• Provide safe, easy access to the mixing area (design to contain and facilitate cleanup of PCP dust/chips lost during transmit to the mixing area).
	Shelter	• Provide storage in an enclosed, secure area, segregated from other chemicals (design to prevent infiltrating precipitation). • Design to preventive fire in PCP storage areas (use of non-combustible construction materials is preferred).
	Ventilation	• Provide adequate ventilation for both routine and also emergency requirements.

TABLE 6.2 RECOMMENDED DESIGN FEATURES FOR CHEMICAL STORAGE AREAS (Cont'd)

Storage Format	Design Feature	Recommendation
PCP (cont'd) ° Solid blocks ° Bagged flakes or granules	**Containment/Cleanup Capability**	• Store PCP in a paved, curbed or dyked area with no floor drains (or with effective, positive blocks for drains). • Design surfaces for effective cleanup of spilled material. • Provide a vacuum cleaner system (with filtered exhaust) for cleanup of solids spilled during unloading and transfer operations.
	Security	• Provide effective security against unauthorized access.
	Emergency Response	• Provide appropriate measures for rapid, effective fire control with containment of liquid fire-fighting residues and treatment to required limits before discharge.
Drummed Wastes ° Sludges ° Contaminated debris	**Shelter/Containment**	• Provide a paved curbed area for storing all drummed wastes pending removal for approved disposal (Section 8.1). • Label waste drums and contents. • Provide a covered area or tarps for drummed wastes.
Bulk Sludges	**Location/Shelter**	• Locate storage in an exterior or well-ventilated location.
	Containment	• Provide closed tanks in sound condition. • Install tanks in a containment area with impermeable, cleanable floors. • Provide adequate containment capacity for the worst-event spill. • Block any drains in the containment area; design to collect infiltrating precipitation for treatment to applicable limits prior to discharge (if contaminated).
	Handling	• Provide transfer equipment for clean, safe sludge handling with minimum worker exposure.
	Security	• Provide effective security against unauthorized access and/or release of tank contents.

TABLE 6.3 RECOMMENDED DESIGN FEATURES FOR CHEMICAL MIXING SYSTEMS

Chemical Form	Design Feature	Recommendation
PCP ° Blocks ° Pellets, granules	**Design Objectives:**	• To provide a mixing system with effective spill prevention features. • To provide a mixing system which minimizes worker contact with PCP.
	Configuration	• Mixing by block placement in a closed tank is the preferred method. • Treating vessels are commonly used for mixing.
	Solids Handling	• Provide appropriate equipment for safe, controlled lifting and handling of PCP blocks. • Provide a dry, paved area for plastic wrap removal from blocks. • Provide closed solids handling systems (debagging, transfer) to eliminate direct worker exposure to PCP flakes/granules (if applicable). • Provide a vacuum cleaner system (filtered exhaust) for effective cleanup of PCP dust and chips from handling/transfer operations. • Provide local exhaust system and closed solids handling systems (e.g., flexible covers on hoppers) to eliminate direct worker exposure to PCP flakes/granules during debagging (i.e., as per NIOSH (62)).
	Spill Containment	• Provide all applicable features for "spill containment of bulk liquids" (Chemical Storage Area, Table 6.2).
	Splash Protection	• Discourage open transfer operations. If unavoidable, provide reliable splash protection.
	Emergency Response	• Provide features described in "Emergency Response" Table 6.1).

TABLE 6.4 RECOMMENDED DESIGN FEATURES FOR TREATMENT PROCESS SYSTEMS: GENERAL REQUIREMENTS

Design Feature	Recommendation
Design Objectives:	• To minimize and contain all releases of PCP. • To conform with the National Fire Code of Canada (NFCC).
Shelter, Configuration	• Use exterior treatment tank. • Locate other process equipment and systems in a centralized area. • Provide heated (where necessary) enclosure for process controls with any air emissions vented externally.
Tanks, Piping and Valves	• Provide all spill containment precautions as outlined in Table 6.2. • Engineer system to promote containment and isolation of preservative chemical. • Review Section 4 of the NFCC to determine compliance of the system with National Fire Code of Canada. • Provide effective access and/or containment for all subsurface tanks and piping. • Avoid placement of subsurface tanks and piping in areas with high groundwater levels.
Process Emissions to Air	• Locate treatment tanks to minimize downwind effects either to yard workers or to adjacent properties actively used for residential/commercial purposes. • Install any control equipment as required to comply with applicable and emission limits.
Process Control Area	• Locate the process control area for maximum visibility of treatment system.
Fire Controls	• Provide fire controls as decided on site-specific basis in consultation with the local fire department. Fire fighting residues may contain toxic products of PCP combustion. • Provide containment for contaminated runoff waters and residues generated by firefighting activities (e.g. blockage of storm drains, adjacent ditches).
Weather Protection (winter operations)	• Protect equipment from freezing, particularly where water is or may be present (e.g., water may build up in the bottom valves of the oil transfer system). • Winterize process control area.

TABLE 6.5 RECOMMENDED DESIGN FEATURES FOR COMPONENTS OF TREATMENT PROCESS SYSTEMS

Design Feature	Recommendation
Design Objectives:	• To provide fail-safe operation of the treatment system. • To minimize the potential for PCP spills.
Treating Tanks	• Engineer treatment tanks for long-term integrity. • Assure subsurface tanks are secured to prevent uplifting. • Install an effective protection device to prevent overfilling of treatment tanks with preservative. - Install independent overflow indication/alarm/pump interlocks between the treating tanks and the control point (where the tank is not visible from the control point). - Provide containment for collection and direct return to tank overflow - Construct overflow connections as per 5.13.3 of the NFCC. • Provide corrosion protection of underground steel tanks as per NFCC 4.3.9. • Provide for tank lids to reduce vapor emissions and to reduce rainfall/ snowfall into tanks. - Construct lids as per sections 5.13.2.4 to 5.13.2.7 of NFCC. • Provide walkway grates (or alternative design) to prevent worker contact or tracking of chemicals. • Provide guardrails and other safety measures as required by provincial authorities for operations near open tanks. • Provide means to contain frothing and/or overflows.
Piping and Recycle Systems	• Design an overall system which is effective at containing and recycling all chemicals with minimum potential for release and dispersal and minimum infiltration of water. • Select and install piping as per Table 6.2.
Process Controls	• Design for simple, unambiguous operation (regardless of the degree of automation). • Establish a clear relationship betweeen process controls and process functions in order to minimize operator error (e.g., provide flow diagrams for process).

TABLE 6.6 RECOMMENDED DESIGN FEATURES FOR TREATED WOOD STORAGE AREAS

Design Feature	Recommendation
Design Objectives:	• To minimize losses* of preservative chemicals from treated wood by: - providing proper conditions for containing drips from freshly treated wood, and - controlling the generation and disposal of contaminated runoff waters. • To comply with National Fire Code of Canada (NFCC) requirements.
General Design	• Integrate consideration of design requirements for: - efficient drip and runoff collection and containment (if necessary), - efficient and safe movement of treated wood.
Storage Areas	• Locate unsurfaced above-ground storage areas away from surface water bodies. • Routinely monitor containment levels in storage area runoff. Make provision for collecting and treating storm runoff if unacceptable levels of contamination occur. • Store wood as per subsection 3.2.2 of the NFCC e.g. - "storage site shall be level, solid ground, paved or surfaced with material such as cinders, gravel or crushed stone" - "yard storage areas shall be separated from mill operations and other structures by an acceptable clear space permanently available for fire fighting operations" - "storage site shall be maintained free of combustible ground vegetation including grass and weeds for at least 4.5 m from the stored material and at least 30 m from bush or forested area" - "lumber treated with combustible liquids shall be stored in piles separated from other stored material,...not less than 4.5 m" - "at least 2 fire department access routes shall be provided"

* The nature and magnitude of drippage losses depend strongly on oil and wood types, and on process-specific factors.

7 OPERATION

In addition to the design objectives described in Section 6, a PCP thermal wood preservation facility should develop operating procedures to protect both workers and the environment from potentially harmful exposure to PCP solutions. The operating procedures would:

a) minimize direct contact of personnel with wood preserving chemicals;
b) minimize releases of wood preserving chemicals to the environment; and
c) facilitate clear and accurate definition of responsibility and action when emergency response is required.

Recommended operating practices are presented in Tables 7.1 to 7.4 and include:

- General practices (Table 7.1)
- Procedures for handling and storing wood preservation chemicals (Table 7.2)
- Practices for operating process systems (Table 7.3)
- Practices for maintenance, cleanout and shutdown of preservation systems (Table 7.4)

The recommendations provided in these tables may not be the sole options available to attain the objectives. Alternative approaches may be equally effective or more suitable in view of site-specific conditions. When programs are developed for a particular facility, the recommendations may be modified if it can be demonstrated that an alternative approach, more suitable to plant specific conditions, would be equally effective in attaining the desired objective.

Consistent with the stated intent of this document, it is recommended that all existing and new wood preservation facilities meet the specific objectives outlined in Tables 7.1 to 7.4 by implementating the recommended practices or their equivalents. Detailed operating procedures for each facility should be incorporated into a written operations manual that is available to all personnel who may have contact with PCP and/or responsibilities for any decisions involving the management and use of PCP. Responsibility and accountability for implementing procedures should be clearly assigned to supervisory personnel and to workers.

TABLE 7.1 RECOMMENDED GENERAL PRACTICES FOR OPERATING PENTACHLOROPHENOL THERMAL TREATMENT FACILITIES

Operation	Recommendation
Personnel	**Objective:** To enhance worker protection by providing education and medical surveillance.
	• Train all foremen, on-scene supervisors, operators, and handlers in good work practices.
	• Provide pre-employment medical check-up and annual on-going medical surveillance (see Section 4).
	• Provide periodic review and update of education and training.
Procedures	**Objective:** To assure that worker responsibilities are well understood, and that site-specific procedures are available in hardcopy for reference.
	• Prepare (and have readily available) explicit written instructions for all aspects of chemical use, facility operation, maintenance and emergency response.
	• Identify and communicate precautions for all other on-site handlers of treated wood (including quality control personnel, sorters, and transporters).
Signing	**Objective:** To assure clear and accurate signing in all wood preservation use areas.
	• Identify the contents of all tanks (e.g., "PCP treating tank", "carrier oil tank").
	• Identify the function of each tank (e.g., "storage tank", "mix tank").
	• Prominently display personnel safety precautions and first aid procedures.
	• Prominently display emergency response procedures.
	• Prominently display emergency telephone numbers for medical aid, facility management, local environmental control agencies.
Personal Hygiene and Safety Precautions	• Follow precautions outlined in Section 4 (Table 4.2).
Housekeeping	**Objective:** To maintain a clean, orderly site
	• Define and practice regular housekeeping standards (suggest daily). - Contain all contaminated debris. - Minimize generation of waste (e.g., don't accumulate empty drums and wrappings)
	• Visually inspect for, record and report leaks at least daily as per sub-section 4.4.11.8 of the National Fire Code of Canada (NFCC)
	• Contain and repair all leaks
Spill Response	**Objective:** Maintain a state of readiness in case of a chemical spill.
	• Develop a spill contingency plan with consideration of NFCC Subsections 4.1.6, 4.1.9 and 4.4.11, and in consultation with regulatory agency and local municipality and authority.

TABLE 7.1 RECOMMENDED GENERAL PRACTICES FOR OPERATING PENTACHLOROPHENOL THERMAL TREATMENT FACILITIES (Cont'd)

Operation	Recommendation
Record Keeping	**Objective:** • To provide a secondary level of control for chemical losses. • To enable a rapid assessment of potential hazards, in the event of a catastrophic incident (e.g., tank rupture, fire, etc.).
	• Maintain accurate daily records for: - Chemical delivery, use and inventory - Equipment condition and maintenance
	• Record and compare bulk tank volumes before and after facility shutdowns in excess of two days (NFCC Subsection 4.3.17 requires weekly measurements and gain or loss computation records for two years for examination by jurisdictional authority). - If changes in volume are apparent, check for tank leaks and/or irregular. practices.
	• It is a practice at some facilities to compare actual versus estimated chemical retention by wood. (If actual greatly exceeds estimated quantities, efforts are made to determine if leaks or poor operating practices exist.)
Fire Fighting	**Objective:** To maintain a state of readiness in case of fire emergency
	• Establish a fire contingency plan (Section 10) as required in subsection 4.1.5.7 of the NFCC and undertake all necessary action to maintain a state of readiness to implement the plan in case of emergency (provide ready access to appropriate fire-response equipment, e.g., foam extinguishers; carry out routine checks of firefighting equipment; and undertake drills with all affected personnel).
	• Liaise with the local fire department, with regard to chemicals in storage and use, and emergency procedures.
	• When a fire alarm call is made, notify firefighters of chemical quantities in stock and verify storage locations.
	• Require self-contained breathing apparatus for all personnel exposed to smoke (only trained fire-fighting personnel should be allowed at the fire scene).
	• Make advance preparation to contain and properly dispose of contaminated fire residues. - Fire sites should be assessed for the presence of toxic residues before undertaking cleanup activities. Both environmental safety and worker protection should be considered. (Fire residues of PCP-containing materials may contain PCP and/or toxic products of incomplete combustion, including chlorinated dioxin and chlorinated furan compounds.). - Runoff water soot and ash PCP-Oil from fires at creosotes storage areas are presumed to be contaminated and should be contained. - Dispose of contaminated firefighting waters as "contaminated runoff" (Table 8.1). - Dispose of non salvagable solid treated wood fire residues as "contaminated solid wastes" (Table 8.1).

TABLE 7.2 RECOMMENDED OPERATING PRACTICES FOR CHEMICAL HANDLING AND STORAGE

Operation	Recommendation
Unloading Chemicals • PCP Solids • CSA 080-201-83 Petroleum oil	**Objective:** To ensure that treatment chemicals are unloaded in a safe manner (Section 4 of the National Fire Code of Canada (NFCC)). • Ensure that the delivery of preservation chemicals is undertaken by personnel who are trained in emergency response procedures (as required by Federal Transportation of Dangerous Goods Regulations (TDGR). • Ensure personnel engaged in transfer of carrier oil are trained as per subsection 4.4.11 of NFCC, i.e., emergency procedures, attention during unloading, operation of fire protection equipment and emergency shutoff valves. • Consult with Section 4 of the NFCC regarding transfer operations of combustible materials via different modes of transport - e.g., rail, truck, ship unloading procedures, grounding, etc. • Assure that ready access to emergency advice and aid is available during all chemical unloading periods, i.e. train employees in standard procedures for normal operations as well as for emergencies and post procedures in printed form for reference (4.4.11 of NFCC and Section 9.7 of the TDGR). • Restrict access to the unloading area during chemical transfer operations. • Prohibit nearby pedestrian or vehicle traffic.
Handling of Wood Preservation Solutions	**Objective:** To assure worker safety during handling of PCP and PCP/oil solutions. • Follow the personnel safety precautions for all procedures (Table 4.2). • Avoid inhalation, ingestion or skin contact with PCP or PCP/oil solutions. • Store empty PCP bags, wrappings or containers in drums and dispose of highly contaminated in accordance with Section 8.
Storage of Wood Preservation Chemicals • PCP Solids • CSA 080-201-83 Petroleum oil	**Objective:** To assure that all PCP and PCP/oil of solutions are safely stored. • Assign responsibility for storage areas to trained personnel. • Label storage areas and tanks with the identity of contents by chemical name, type of solution and concentration (e.g., PCP, PCP/oil work solutions (3-6%)). • Place chemical identity placards, fire or spill emergency response procedures, personnel safety precautions and first aid procedures at storage room entrances and/or at storage areas. • Implement visual inspection routine at least once each shift for prompt detection of abnormal conditions (as per NFCC 4.4.11.7). • Frequently inspect and test all safety shutoff valves and other fire safety devices (as per NFCC 4.4.11.9). • Check and maintain the integrity of storage tanks and storage containers. - Clean up all leaks or spills and implement remedial actions immediately. - Check liquid levels in storage tanks weekly. Compare measurements with meter readings. Compute gains or losses of liquid, as per NFCC 4.3.17. - Contain all spilled PCP solids (dust, chips) and reuse or dispose of as contaminated solid waste. • Provide secure storage areas for PCP; allow access by authorized personnel only.

TABLE 7.3 RECOMMENDED OPERATING PRACTICES FOR PROCESS SYSTEMS

Operation	Recommendation
Routine Checks	**Objectives:** • To define practices to enhance environmental protection and worker safety. • To comply with the National Fire Code of Canada (NFCC).
Worker Safety	• Follow all precautions listed in Table 4.2.
Work Solutions	• Regularly check and record quantities of treatment solution in storage as per NFCC 4.3.17.
All Process Components	• Visually check the complete system for leaks as per NFCC 4.4.11.7. - Take immediate action to stop leaks. • Check sludge levels in treating and solution storage tanks. - Clean out as required, in accordance with facility policy. - Observe personnel safety precautions (See Table 4.2).
Tank Vents	• Test tank vents to regularly assure the absence of blockage (suggest once per month).
Charges	• Secure loads to avoid uncontrolled floating. • Stack loads to allow good drainage of preservative from all wood surfaces after treatment.
Treating Tank Lids	• Place tight-fitting lids on tanks to minimize the release of vapours.
Checks During Treating	**Objective:** To monitor the treatment system to identify potential/actual problems.
System Integrity	• Closely monitor process systems for leaks during initial stages of treatment. • Closely monitor treating tanks for overflow and frothing. • Check for leaks at least once per shift or once per charge (whichever is most frequent), (as per NFCC 4.4.11.7 and 4.4.11.8). • Compare instrument readings with indicating gauges and thermometers. • Note malfunctions of recording devices, thermometers, gauges (including level floats) and arrange for prompt repairs. • Maintain records of treatment cycles, temperature readings, and chemical consumption. • Define (in writing) operator actions for abnormal situations of concern (e.g., response to equipment breakdown).

TABLE 7.3 RECOMMENDED OPERATING PRACTICES FOR PROCESS SYSTEMS (Cont'd)

Operation	Recommendation
Post-treating Checks	**Objective:** To prevent worker contact with treatment solution and with freshly charged loads.
Quality Control (entry into treatment tanks) or Load Removal Problems	• Do not enter treating tanks until the tank has cooled. - If tank TLV levels are unknown, or at or above regulatory TLV levels, the attendant must wear a self-contained full-face respiratory mask, disposable coveralls, impermeable boots and gauntlets. • If TLV levels are less than regulatory limits, wear an approved respirator, disposable coveralls, impermeable boots and gauntlets. • Assure presence of a standby attendant. • Shower immediately after tank entry.
Charge Removal	• Allow ventilation of the charge before unloading by exposing the open tank to air. • Minimize exposure to vapours by working upwind of the charge and/or wearing an approved respirator. • Wear impervious gauntlets during handling of freshly treated charges. • Maximize use of mechanical equipment for charge removal to minimize need for worker handling of freshly treated wood. • Remove charges only when the superficial excess preservative has drained.

TABLE 7.4 RECOMMENDED OPERATING PRACTICES FOR MAINTENANCE, CLEANOUT AND SHUTDOWN OF TREATMENT SYSTEMS

Operation	Recommendation
Equipment Maintenance	**Objective:** To assure that equipment is maintained in a manner that will minimize releases of PCP/oil solution and minimize worker exposure to PCP and its byproducts.
	• Maintain all equipment in good operating condition. • Prepare explicit written maintenance procedures and schedules with assigned responsibility and accountability. • Adhere to all personnel safety precautions during maintenance (Table 4.2). • Remove all wood preservation chemicals from equipment prior to maintenance. - If applicable, dispose of wash waters as contaminated liquids. • Use extreme caution if contaminated equipment must be welded (toxic fumes can be generated). - Comply with NFCC 4.4.11. - Thoroughly clean surfaces to be welded. - Wear an approved respirator when welding surfaces that have contacted PCP. - Provide good ventilation in the work area. - Contain all sparks and remove flammable materials from the vicinity of the repair area. • Check integrity of subsurface thermal tanks (e.g., by sand blasting tanks) at least once every two years (cracks will be visible in cleaned tanks).
Cleanout	**Objectives:** • To prevent accumulation of PCP solutions and sludges within the treatment system. • To assure worker safety during cleanout operations.
	• Observe personnel safety precautions during all procedures (Table 4.2). • Routinely inspect sludge levels in storage and mix tanks and cleanout if required. Determine and specify sludge levels requiring removal in consultation with qualified technical personnel. - During cleanup, inspect gauge floats or similar tanks. • Routinely inspect treating tanks for sludge accumulation and clean out if required. • Thoroughly cool tanks prior to entry. - If airborne concentrations are unknown, at, or above TLV's, attendent must wear self-contained breathing apparatus, impermeable gloves, boots + coveralls. - If airborne concentrations are below TLV's wear approved respirators, impermeable gloves, boots, and coveralls. - Provide a constant standby attendant and continuous outside communication. - Follow standard safety procedures for entry of confined spaces. - Prevent skin contact with sludges. - Remove sludges with equipment used only for facility related purposes. - Collect, drain, and store contaminated material in sealed drums pending disposal (Table 8.1). - The attendant should shower immediately after cleaning retorts or tanks. - Thoroughly clean (e.g., by sandblasting) treatment tanks interiors (suggested biannually) to facilitate the inspection for structural integrity.
Alarms	• Test all alarms and safety devices regularly (or as specified by manufacturer).

TABLE 7.4 RECOMMENDED OPERATING PRACTICES FOR MAINTENANCE, CLEANOUT AND SHUTDOWN OF TREATMENT SYSTEMS (Cont'd)

Operation	Recommendation
Long-term Shutdown	**Objective:** To ensure orderly shutdown prior to long-term closure.
	• Thoroughly drain and clean all equipment which has been in contact with preservatives. • Where applicable, collect all solvents and wash-waters generated by cleanup operations (e.g., steam cleaning) (Table 8.1). • Hold solutions in closed tanks for prolonged shutdown. - Drain all open tanks or sumps to closed storage tanks. - Provide adequate freezing protection for all piping and vessels containing or potentially containing water (as applicable; e.g., assure that condensed or trapped water cannot freeze and rupture piping). • In case of permanent shutdown, reuse of treatment solutions at another facility is preferred to disposal.

8 PROCESS EMISSIONS

8.1 Control, Treatment, and Disposal

The PCP oil-borne thermal treatment process generates solid wastes and emissions to air. No liquid process wastewaters per se are generated. Numerous approaches are used or can be used by the industry to control, treat and/or dispose the process wastes and emissions. Potential sources of chemical releases from PCP thermal treatment facilities are described in Section 2.2 and Figure 2.2 of this document. Table 8.1 identifies the main categories of process wastes or emissions that can be generated at PCP facilities, and summarizes recommended control, treatment and/or disposal methods.

8.1.1 Handling of Waste Liquids Containing PCP.

Liquid Process Wastes - Leaks and drips of oil solutions generally do not occur during the thermal treatment of wood. Frothing and/or overflow from the treatment tank can occur. The thermal tank should be designed to accommodate containment of such overflow. Structural defects in the treatment tank can also result in releases of oil solutions to groundwater. Containment shells would prevent groundwater contamination. Contaminated water solutions may be generated, such as wash waters and waters that infiltrate subgrade containment shells, requiring removal of oil and PCP from wastewaters prior to discharge (1,2,3). The techniques may include one, or a combination of:

- oil/water API separation,
- activated sludge treatment,
- activated carbon treatment, and/or
- physical-chemical treatment (i.e., flocculation).

A regulatory discharge permit must be obtained for disposal of the treated aqueous wastes.

Contaminated Storm Runoff - Because thermal treatment facility sites are generally large, considerable volumes of storm runoff waters occur from these sites. Every precaution should be taken to avoid contamination of storm runoff water, particularly in the vicinity of PCP storage sites and treatment areas. A possibility of PCP-contaminated runoff from treated wood storage areas must be acknowledged; surface runoff from the storage areas should be monitored for chlorophenols and oil. If contamination is

TABLE 8.1 RECOMMENDED DISPOSAL PRACTICES FOR PCP-CONTAMINATED WASTES

Waste Category	Examples	Recommendation
Liquid PCP/Oil Solutions	• Spilled PCP/oil concentrates • PCP work solutions • Drips from freshly-treated lumber • Material skimmed from oil-separators	• Collect and reuse.
Liquid PCP-Water Solutions	• Wash waters • Infiltrating waters	• Treat to remove oil and PCP to within regulatory limits. • Dispose of treated waters as per regulatory requirements.
Contaminated Solid Wastes	• Debris and bottom sludge from storage tanks, sumps and thermal tanks • Soils contaminated by spills • Clean-up absorbents • Sludges from wastewater treatment processes • Solid fire residues from PCP or PCP-oil storage areas • Unrinsed bags, containers or wrapping used for solid PCP	• Drain and/or drum, store and dispose in accordance with provincial regulatory requirements (high temperature thermal destruction appears to be the most feasible disposal option).
Miscellaneous Solid Wastes	• Empty containers, bags and wrapping rinsed with alkaline water • Scraps, cuttings and shavings from PCP-treated lumber	• Dispose of in sanitary landfills (subject to approval by the provincial regulatory agency).
Contaminated Storm Runoff	• Storm runoff or contaminated liquid discharge containing PCP at concentrations exceeding 0.1 mg/L or that is determined to be toxic to fish at point of discharge (toxicity is determined by bioassay tests)	• Prevent or minimize contamination of storm runoff to greatest possible extent. • Monitor surface water discharges (in consultation with the provincial regulatory agency) to assess contaminant concentrations and determine the need for control.
Fire-fighting Water Runoff	• As above (contaminated storm runoff)	• Consider provisions for containment where PCP and PCP-oil solutions are present. • Consult with provincial regulatory agency to determine acceptable disposal practices.
Air	• Dust from debagging	• Provide local ventilation.
	• Vapours from thermal tank during the hot oil treatment process • Vapours from freshly treated charges	• Use tank covers during process. • Provide respiratory equipment for workers.
	• Tank vent vapours	• Provide vapour traps for hot liquid tank vents and vacuum exhaust. • Vent tank vapours (cold storage) to outside as per NFCC Subsection 4.3.5.
	• Evaporation of wastewaters	• Consult with provincial regulatory agency.
	• Open burning of sludges, debris	• Prohibit.

evident, and if the runoff is directed to a waterbody or a storm sewer, the need for control of the discharge will have to be determined in consultation with the appropriate regulatory agency.

Control Requirements - Control specifications will depend upon factors such as the volume and frequency of the discharge and the sensitivity of the receiving environment. Appendix A reviews existing Canadian regulatory limits for discharges of chlorophenols and petroleum based oils. The discharge of chlorophenol-contaminated emissions into waters inhabited by fish is subject to the provisions of Section 33(2) of the Federal Fisheries Act. Chlorophenol concentrations (total penta- and tetra-) in the order of 100 parts per billion are acutely lethal to fish (55); concentrations above such levels would likely be defined as deleterious substances under Section 33(2) of the Act.

8.1.2 Disposal of Solids With Potentially High PCP Concentrations. For the purposes of this document, solids with "potentially high levels of PCP" are defined as:

- sludges from work solution tanks and the treatment tanks,
- sludges from wastewater treatment processes (e.g., flocculated material), and
- unwashed bags, containers or wrappings for PCP.

Sludges from thermal tanks constitute most of the solid wastes at thermal facilities. Operating and design modifications can be used to significantly reduce the volume of sludge. For example, open exposure of the tanks to precipitation leads to the generation of higher volumes of sludge.

Pending the establishment of approved special waste disposal facilities in Canada, this document provides interim guidelines for the disposal of solid PCP wastes. These guidelines are subject to periodic review or change in light of the ongoing development of specific regulations in each province for managing hazardous wastes.

Guidelines for disposal of solid wastes - While awaiting disposal the contaminated solids should be stored in leakproof containers in a specially designed area which is curbed and lined with impermeable material. The area should be roofed or covered by a plastic leakproof tarpaulin to protect the wastes from precipitation. Any seepage or leachate generated at the site should be contained.

The most feasible disposal option for chlorophenol wastes appears to be high-temperature thermal destruction. A joint provincial/federal/industry task group is currently studying the production of toxic by-products (polychlorinated dibenzofurans and polychlorinated dibenzo-p-dioxins) that may be generated during the incineration of

chlorophenol compounds. The joint task group will ultimately develop specific recommendations for proper disposal of wastes containing chlorophenols. Pending these recommendations, regulatory agencies should consider specific requests to incinerate chlorophenol-containing wastes on a case-by-case basis. The U.S. EPA standards for incineration of hazardous wastes can be used as a guideline to evaluate the suitability of these requests. These standards include (but are not limited to) the requirements for a minimum incineration temperature of 1000°C and a minimum residence time of 2 seconds. Such conditions have also been successfully used for destruction of dibenzofurans and dibenzodioxins (63). Siting of the incinerator must also be taken into account.

Guidelines for incineration technology assessment, operation and siting are being drafted by Environment Canada for PCB incineration and these guidelines also could be used as a basis for PCP incineration (64). Incineration of PCP-contaminated solids will require the specific approval of the appropriate provincial agency.

8.1.3 Disposal of Miscellaneous Solid Wastes. Miscellaneous solid wastes (e.g., wrappings or empty pellet drums rinsed with alkaline solution, cuttings from PCP-treated lumber) from PCP-wood preservation plants may be disposed at designated sanitary landfills as approved by the provincial regulatory agency.

8.1.4 Control of Air Emissions. Air emissions at thermal treatment facilities are generally localized; effects, if any, would be restricted to workers at the facilities. Such emissions include:

- vapours from thermal tanks during hot oil treatment process,
- dust from manual debagging,
- vapours from tank vents,
- vapours from freshly treated charges.

Design and procedural recommendations for control of these localized emissions are suggested in Sections 6 and 7.

If open burning of sludges occurs at a facility, widespread dispersal of contaminants could occur. It is suggested that such practices be prohibited .

8.2 Emission and Site Monitoring

Site monitoring and assessment is required at PCP facilities to verify that the wood preservative chemical is being properly managed (in accordance with the design and operating objectives described in this document). Archiving of the assessment records

also will provide an orderly evaluation of site decommissioning activities, if plant shut-down does occur.

Environmental monitoring for PCP-facilities would normally be developed in consultation with the appropriate provincial environmental regulatory agency. Additional consultation would be required with Environment Canada if the facilities have a potential to affect federally-managed resources (e.g., facilities located on or adjacent to Indian lands, or facilities located adjacent to waters used by anadromous fish such as salmon). Worker health monitoring requirements would be developed in consultation with a Provincial Workers' Compensation Board and/or Department of Labour.

The level of detail and scope of these monitoring activities depends on site characteristics, facility design, and the requirements of the regulatory agencies. Tables 8.2 and 8.3 suggest components of a site environmental and worker health monitoring program.

Analytical methodologies proposed for use must be approved by the regulatory agencies. In addition to PCP, constituents (analytes) for identification and quantification should include some indicators of petroleum oil contamination (e.g., oil and grease analyses as per methods 503 B or 503 E in Standard Methods (65)). Procedures for PCP quantification should recognize existing state-of-the-art (e.g., Jones (18)). For example, Standard Methods does not recommend use of the 4-aminoantipyrine colorimetric method for quantifying PCP. All analytical data requires documentation which will (1) trace the sample from the field to the final results, (2) describe the methodology used, (3) describe the confirmatory evidence, (4) support statements about detectability, (5) describe the quality assurance program and demonstrate adherance to it, and (6) support confidence statements for the data (66).

TABLE 8.2 SUGGESTED ROUTINE ENVIRONMENTAL MONITORING

Item	Recommendation
Authority/Reporting	• Develop a site-specific monitoring plan in consultation with the appropriate regulatory agency. • Define reporting requirements. • Re-evaluate the plan if the facility expands or changes design or operating practices.
Soils	• Consider implementing a soil monitoring program (with emphasis on unsurfaced grounds) including: - all areas where preservative chemical is routinely stored, processed or handled, - all freshly-treated lumber storage areas, - all treated wood storage areas, and - drainage ditches or areas exposed to surface runoff (including overflow from drip pads and paved areas). • Define sampling frequency (e.g., annual), sample type (e.g. surface, core), and required analyses (e.g., constituents, detection levels, quality control) in consultation with the regulatory agency.
Surface Waters	• Consider implementing a monitoring program for adjacent water bodies. - Define monitoring frequencies and required analyses (e.g., constituents, detection level, quality control) in consultation with the regulatory agency. - Define concentrations of concern.
Groundwaters	• Consider implementing a groundwater monitoring program using permanent monitoring points down-gradient of unpaved process areas and treated lumber storage areas. - Define well construction. - Define sampling frequencies and required analyses (e.g. constituents, detection levels, quality control). • Give special attention to on-site wells used for drinking water.
Air Emissions	• Identify air emission sources by use of data provided in air inhalation exposure assessments as per Table 8.3. • Define monitoring objectives and monitor as required for all points of emission governed by air emission permits.
Liquid Waste Streams	• Identify liquid waste discharges (including stormwater runoff) and determine: - concentrations of preservative constituents (PCP and petroleum oil), - estimations of flow rates, and - sampling protocols. • Monitor as required for all discharges governed by permits.
Solid Wastes, Sludges	• Maintain current, complete records for all solid wastes stored on-site (pending disposal). • Determine chemical and physical characteristics of wastes. • Undertake all reporting and disposal activities required by applicable regulations.

TABLE 8.3 SUGGESTED ROUTINE WORKPLACE MONITORING

Item	Recommendation
Authority/Reporting	• Develop a facility-specific plan in consultation with the regional workers compensation board office. • Define reporting requirements.
Contact Exposure	• Identify existing and potential sources of skin exposure by periodic walk-through inspections.
Air Inhalation Exposure	• In consultation with the regulatory agency responsible for worker safety, define the design of an initial monitoring program (e.g. sampling techniques, frequency of sampling, etc.). • For the purpose of defining worker health protection measures, provide an initial evaluation of peak and average levels of preservative constituents in air at significant points of worker exposure including: - work areas around thermal tanks, - PCP handling areas (e.g., during period of debagging), - receiving areas for all vents/exhausts which discharge to areas frequented by personnel (including interior spaces receiving drift from exterior emission sources), - all enclosed preservative process areas, and - areas adjacent to freshly-treated wood storage. • Make personnel samplers available for spot monitoring (as required) if high emission levels are suspected.
Biological Monitoring	• Conduct initial screening physical exams to identify sensitive individuals (Section 4). • In consultation with the regulatory agency, define a schedule for: - medical exams to confirm the absence or signs of symptoms of exposure to preservative constituents, and - biological monitoring of workers for preservative constituents (e.g., PCP concentration in urine).

9 TRANSPORTATION OF PCP SOLIDS, SOLUTIONS AND WASTES

The transportation of PCP solids, solutions and wastes generated by their use is regulated under the Federal Transportation of Dangerous Goods Act (TDG). The Act does not apply to the transportation of lumber and forestry products treated with preservatives (67). The regulation of intra-provincial movement of dangerous goods is a provincial responsibility.

Transported dangerous goods must be classified according to the TDG regulations. Regulatory requirements for elements such as shipping, documentation, placarding and personnel training were published in the February 6, 1985, *Canada Gazette* (68). Table 9.1 provides a brief overview of the regulatory requirements.

Table 9.2 suggests more specific transportation procedures for pentachlorophenol which are based on good operating practice and which complement the 1985 Transport of Dangerous Goods Regulations. It is the intent of these control measures to minimize the potential for accidental release in transit and to provide an effective mechanism for safely managing spills if they do occur.

TABLE 9.1 TRANSPORTATION OF DANGEROUS GOODS APPLICABLE TO PENTACHLOROPHENOL

TDGA Reference*	Subject	Brief Description
4.4, 4.8	**Shipping Documentation**	Shipping document to indicate (in part): primary classification number; special instructions for safe handling, transportation, and storage; 24-hour telephone number for information concerning damaged or defective containers; placard requirements.
4.9	**Identification of Active Constituents**	Where dangerous goods are a systemic poison, the technical name of the active constituents shall be included.
4.15 - 4.18	**Shipments of Wastes**	A manifest is required for the shipment of more than 5 kilograms of solid wastes or more than 5 litres of liquid wastes.
4.19	**Empty Containers/Vessels**	Cleaning and purifying of residues from containers and vessels is required until "no hazard exists"; containers and vessels to be signed as "empty - last contained PCP".
4.22	**Rail Transport**	Railway crews are to be notified of the position within the train of vehicles containing dangerous goods.
4.23	**Location of Documentation During Transport**	Documents to be in cab door of truck.
4.24 - 4.26	**Delivery of Dangerous Goods**	Provision of consignee with documentation.
4.27	**Retention of Documentation**	Document to be retained for two years.
5.2	**U.S. - Canada Shipments**	Compliance with all aspects of the TDGA is required.
5.5 - 5.15	**Labels**	Label requirements are specified.
5.16 - 5.3	**Placards**	Placard requirements are specified.
7.4	**Incompatibility**	Shipment with incompatible goods is not allowed.
7.14	**Transborder Consignment of Wastes**	Imports and exports require notice in writing to the Director General (Transport Canada TDG).
9.2 - 9.3	**Personnel Training**	Handling, transport to be conducted only by trained personnel.
9.8	**Registration**	Each importer of dangerous goods must register with the Director General (Transport Canada TDG).
9.13 - 9.14	**Dangerous Occurrence Reporting**	Dangerous occurrences (e.g., spills) involving more and 5 kilograms or 5 litres of solids, solutions or wastes must be reported immediately (see Appendix for reporting authority).

* Transport of Dangerous Goods Act section number (' February 1985).

TABLE 9.2 RECOMMENDED TRANSPORTATION PRACTICES FOR PCP-CONTAINING SOLUTIONS OR WASTES

Feature	Recommendation
Container Specifications	• Container for transporting PCP must be: - filled and closed in the manner prescribed for Wood Preservatives by the "Regulations for the Transportation of Dangerous Commodities by Rail", 1986, as amended, published by the Canadian Transport Commission. • Bags, blocks or containers of PCP should be protected from physical abuse to prevent spillage of material. • Drums or tanks for transporting PCP-containing wastes must be free from mechanical defects.
Container Labelling	• The Transportation of Dangerous Goods Act stipulates specific label requirements. • Affix the appropriate labels, depending on classification, to each container. • Label each container on at least two sides.
Vehicle Placarding	• Affix the proper placards to vehicles carrying 500 kilograms or more of any material (solutions or wastes) containing PCP. Note: Vehicles carrying PCP-treated commodities need not be placarded.
Securing Vehicle Loads (i.e., drummed wastes)	• Wrap bags to secure to pallets. • Strap drums or blocks vertically to pallets. • Strap drums horizontally to each other. • Brace or tie down loads to prevent shifting. (Do not rely on the vehicle floor or sides to prevent shifting.) • Ensure a stable load consistent with the vehicle floor strength. • Secure other load items to prevent drum punctures.
Responsibilities of Truck Driver, Ship Captain or Railroad Crew	• Know the nature of the load. • Carry suitable emergency equipment and be trained in its proper use. • Know and follow correct procedures for the reporting of accidents or spills. - Immediately telephone the 24-hour contact identified in the shipping manifest. - If more than 5 kilograms is spilled, also telephone the emergency contact identified in Appendix. - Know and comply with any other requirements of the shipper/manufacturer. • Immediately replace lost or damaged placards or labels (carry spares). • Notify the receiver of goods that PCP materials are in transit. (Note: Some provinces allow only licensed carriers to transport hazardous wastes.)
Loading Procedures	• Ensure that personnel have the means and ability to transfer bulk materials safely. • Assure that all procedures involving transfer of oil or PCP oil solutions are in accordance with Section 4.11 of the National Fire Code of Canada. • Set vehicle handbrakes securely and place wheel blocks prior to unloading. • Require the presence of a person who knows the hazards of PCP and who is trained and prepared to respond to spills and other emergencies. • If leakage or spillage occurs, decontaminate the vehicle prior to returning it to service. • Dispose of absorbants and spill cleanup materials as per Table 8.1.
Manifest Requirements	• Transport of Dangerous Goods Regulations require a manifest. See Table 9.1 and the 06 February 1985 *Canada Gazette* for specific details.

10 SPILL AND FIRE CONTINGENCY PLANNING

It is recommended that facilities using PCP prepare a detailed contingency plan to ensure that response to spills and fires is safe and effective. Although details of a contingency plan would be facility-specific, the following sections outline the provisions that should be found in a typical spill contingency plan. It is recommended that the individual facility plan be filed with the authority having jurisdiction.

10.1 Spill Contingency Planning

10.1.1 General Requirements. A contingency plan should:

1. Have policy, purpose and organizational structure.
2. Be geared to the most probable spill size.
3. Address the following phases of spill response:
   - discovery and notification;
   - evaluation and initiation of action;
   - containment and countermeasures;
   - cleanup, mitigation and disposal;
   - documentation and cost accounting.
4. Clearly assign duties and roles to responsible personnel and organizations.
5. Outline equipment requirements for spill control.
6. Include procedures for updating the plan on a scheduled basis.
7. Outline training requirements for plant personnel in prevention and response.
8. Co-ordinate with other chemical spill prevention plans and procedures if appropriate.
9. Be submitted to chemical suppliers and the cleanup contractor or consultant for review.
10. Subsequently be submitted to appropriate government agencies including the local fire department for review.

10.1.2 Implementation Capability. A contingency plan should:

1. Describe location, capability and limitations of cleanup and containment equipment.
2. Pre-arrange for use of the best available cleanup and containment equipment.
3. Identify detailed response options and strategies.
4. Provide for training programs and regular practice sessions.

5. Identity communication requirements with police, fire departments and regulatory agencies.
6. Describe how communications will be maintained among all parties during response operations.
7. Describe steps to be taken as a routine precaution against spills.
8. Address human safety issues.
9. Assign selected personnel to respond to public and media calls.
10. Provide for sampling and data collection for runoff waters and debris.

10.1.3 Environmental Protection and Other Liability Risks. A contingency plan should:

1. Identify high-risk areas and operations.
2. Discuss expected chemical and physical behaviour of spill materials.
3. Identify and priorize sensitive environments for protection.
4. Detail specific actions planned for minimizing damage to resources.
5. Define explicit standards for the components of and extent of effective cleanup.
6. Include provisions for responding to spills under all anticipated weather conditions.
7. Pre-arrange all response capability needed for the estimated worst-case spill.

10.1.4 Examples of Action Steps. Safety of people is of prime concern. If a spill occurs:

1. Stop the flow of any liquids containing PCP;
    - use common sense;
    - act quickly ;
    - shut off pumps, close valves, etc.;
    - if applicable, shut down mechanical production systems first (for example, lumber movement) to prevent injury.
2. Warn people in immediate vicinity;
    - do not allow unauthorized personnel to enter the area;
    - provide proper protective equipment for on-site personnel;
    - avoid any contact with skin, eyes, clothing or shoes.
3. Contain the spill;
    - act promptly;

- block off drains, culverts and ditches;
- surround spilled material with earth, peat, straw, sand, booms, or commercial sorbents;
- use liquid recovery type vacuum cleaner (or use of empty cylinder and vacuum pump) for recovery of pools.

4. Obtain required assistance from:

- company personnel (advise at earliest opportunity);
- chemical suppliers;
- fire/police/public works/highways department/contractors (as required).

5. Notify applicable government agencies;

- prompt notification is especially important for spills which have entered or may enter receiving waters;
- spills to marine waters require contact with Environment Canada;
- for all other spills, contact provincial emergency program office.

6. Commence recovery, cleanup, restoration action;

- recover pools using vacuum systems and contain recovered liquid for re-use;
- use an inert absorbent to complete clean-up;
- collect contaminated sorbent and store as described in Table 8.1;
- carry out clean-up and disposal in consultation with provincial and federal regulatory personnel.

10.2 Fire Contingency Planning

Although PCP is not flammable, work solutions of PCP and P9-66 (CSA 080.201-1983) carrier oil are flammable.

Extreme caution is required at fires involving chlorophenols. If solid PCP is exposed to fire, or if combustion of PCP-oil mixtures occurs, the PCP will decompose, creating hydrochloric acid fumes and possibly dioxins. All fire residues must be considered to be contaminated and contained for analysis and disposal as appropriate (see Table 8.1). It is therefore important for PCP-wood preservation facilities to devise an adequate contingency plan for fire protection. The following sections outline the contents of a typical fire contingency plan.

10.2.1 **General Requirements.** A fire contingency plan should:

1. Be prepared in consultation with local fire authorities.
2. Describe policy, purpose and organizational structure.
3. Assure that PCP is stored in fire protected areas.
4. Be geared to the most probably affected area(s).
5. Assure that proper fire extinguishing agents are available in adequate quantities, i.e., foam.
6. Address the following phases of fire response:
   - discovery and notification,
   - evaluation and initiation of action,
   - clean-up, assessment of contamination, mitigation and disposal, and
   - documentation.
7. Clearly assign duties and roles to responsible personnel and organizations.
8. Include procedures for updating the plan on a scheduled basis.
9. Co-ordinate with other fire prevention plans and programs if appropriate.
10. Be reviewed by local fire department.

10.2.2 **Action Steps.** Fire contingency plans and defined action steps would be site-specific. Nonetheless an overall strategy should include provisions to ensure that:

1. Water only is used to cool fire-exposed containers.
2. Foam, dry chemical (e.g., halon) or carbon dioxide is used for oil fires.
3. Fire-fighters are protected from toxic gas emissions by use of respirators.
4. An evacuation plan is prepared for populations with potential exposure to smoke plume.
5. Contaminated runoff is contained.
6. The provincial emergency program is notified if runoff waters may have entered receiving waters.

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APPENDIX - LEGISLATIVE SUMMARY

The following principal federal and provincial legislation (acts and regulations) address the use, transportation, and disposal of PCP.

Federal Acts

1) Fisheries Act
2) Environmental Contaminants Act
3) Pest Control Products Act
4) Ocean Dumping Control Act
5) Transportation of Dangerous Goods Act
6) Clean Air Act

Provincial Acts

Alberta	1) Clean Water Act 2) Clean Air Act 3) Hazardous Chemicals Act.
British Columbia	1) Waste Management Act 2) Pesticide Control Act 3) Workers' Compensation Act 4) Environmental Management Act
Manitoba	1) Dangerous Good Handling and Transportation Act 2) Clean Environment Act 3) Workplace Safety and Health Act
New Brunswick	Clean Environment Act
Newfoundland	Department of Environment Act
Nova Scotia	1) Environmental Protection Act, SNS, 1973 2) Dangerous Goods and Hazardous Wastes Management Act, SNS, 1986
Ontario	1) Dangerous Goods Transportation Act 2) Environmental Protection Act 3) Health Protection and Promotion Act 4) Lakes and Rivers Improvement Act 5) Ontario Water Resources Act

6) Pesticides Act

7) Occupational Health and Safety Act

Quebec

1) Loi sur la qualité de l'environnement (Environmental Protection Act)

2) Loi sur la santé et la sécurité du travail (Occupational Health and Safety Act)

3) Code de la sécurité routière (Road Safety Code)

Saskatchewan

The province has no legislation specific to the use and disposal of chemicals used in the wood preservation industry. The uncontrolled release of chlorophenols is reportable under the Environmental Spill Control Regulations, 1981, and disposal in municipal landfills is prohibited by the Municipal Refuse Management Regulations' 1986. Chlorophenols products are regulated on provincial highways by the Dangerous Goods Transportation Regulations, 1986. Hazardous Substances and Industrial and Hazardous Waste Management Regulations which will address the storage, treatment and disposal of these wastes by industry are in preparation. These regulations should be in place by 1988.

Figure A.1 provides a schematic overview of regulatory agencies and their responsibilities with respect to PCP wood preservation facilities. Table A.1 presents a brief review of the pertinent sections of the acts and any regulations that have been promulgated under the acts. Table A.2 provides emergency contacts in case of contraventions of the above acts; additional contacts to provide clarification of requirements are provided in Table A.3.

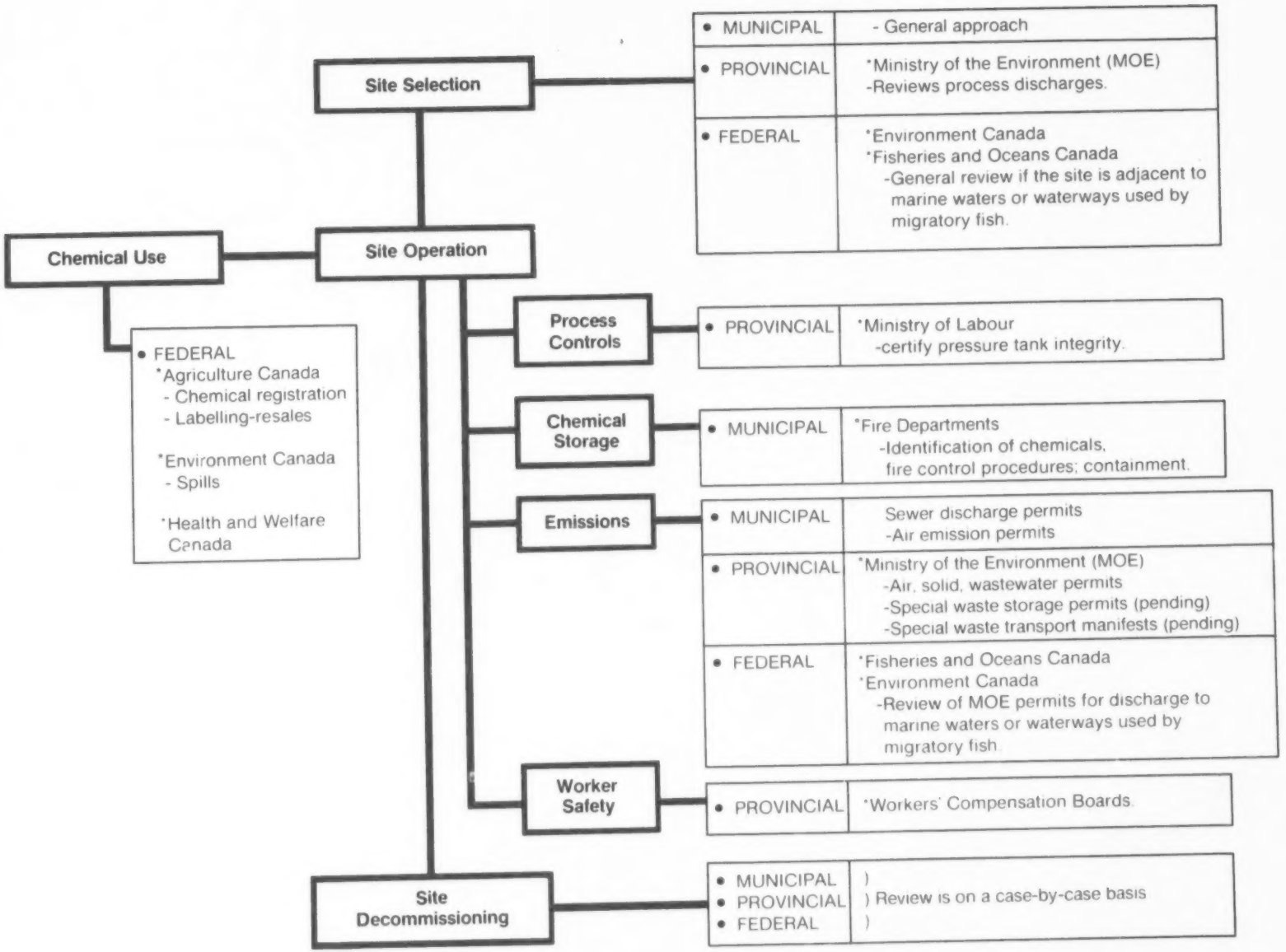

FIGURE A1 AGENCY MANDATES FOR REGULATING WOOD PRESERVATION FACILITIES

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF PENTACHLOROPHENOL

Legislative Act (Responsible Agency)		Relevant Sections	Comments
1.	**Federal**		
1.1	Fisheries Act (Environment Canada and Fisheries and Oceans Canada)	Section 33(1)	If a proposed facility could affect federally managed resources, then Environment Canada (EC) has the authority to review plans for operations and works, to recommend modifications and, if necessary, to prohibit construction.
		Section 33(2)	This Section focuses on the protection of certain fish fish species in marine and fresh waters. It is used by EC and DFO for the prohibition of the discharge of deleterious substances into waterways frequented by fish. Chlorophenols are deleterious to fish and their habitat. Other subsections of the Act may have application if regulations are developed or if specific information is requested.
1.2	Environmental Contaminants Act (Environment Canada, Health and Welfare Canada)	Section 4(1)	The Act gives the federal government authority to investigate and collect information on commercial chemicals pertaining to all facts of production, use, and release into the environment. PCP aromatic hydrocarbon compounds are currently being investigated to determine the nature and extent of the danger that they pose to human health and the environment.
		Section 8	Pursuant to Section 8 the federal government may develop regulations prescribing the maximum quantity of a substance which may be released and the conditions under which the substance may not be imported, manufactured, processed, offered for sale or used.
1.3	Pest Control Products Act and Pest Control Regulations (Agriculture Canada)	Section 5	The Act regulates products used for the control of pests and organic functions of plants and animals. Examples of products are insecticides, fungicides, mulluscides and herbicides. The Act requires that an importer exporter, manufacturer and distributor of a controlled product must register that product with Agriculture Canada. The Regulations prescribe the registration procedures, the information required to be submitted with an application and they define restrictions on the formulation and composition of the products, packing and labelling, product distribution and product use. Chlorophenol wood preservation products are fungicides and must be registered with Agriculture Canada.
1.4	Ocean Dumping Control Act Ocean Dumping Regulations	The Act Section 5	The Act provides the federal government the authority to restrict the dumping of scheduled substances into Ocean waters.
	(Environment Canada)	The Regulations Section 5	Chlorophenols would be included under the category of "Restricted Substances" (pesticides and their by-products not included in Schedule 1). Such substances are considered to be potentially harmful and require special care when dumped into the marine environment.

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF PENTACHLOROPHENOL (Cont'd)

Legislative Act (Responsible Agency)	Relevant Sections	Comments
1.5 Transportation of Dangerous Goods Act and Regulations (Transport Canada)	Section 4 Section 5 Section 26	The Act was proclaimed in 1980 in order to promote public safety in the transport of dangerous goods, such as explosives, flammable materials and toxic chemicals. Sections 4 and 5 define the offences under the Act, and Section 26 provides the federal government the authority to develop regulations and standards. Regulations published in 1985 identify specific requirements for documentation (manifests and waybills), packaging and labelling for nine classes of dangerous goods and wastes.
1.6 Clean Air Act (Environment Canada)	Section 7(1) Section 31	An Act relating to ambient air quality and the control of air pollution. No specific regulations for creosote or any components of PCP.
2. Alberta		
2.1 Clean Water Act (Alberta Environment)		Act provides the legislative basis for the protection of surface and fresh groundwater.
2.2 Clean Air Act (Alberta Environment)		Legislative basis for the protection of ambient air quality and control of air pollution.
2.3 Hazardous Chemicals Act Hazardous Waste Regulations (Alberta Environment)		The disposal of hazardous waste is controlled under this Act and Regulations.
3. British Columbia		
3.1 Waste Management Act (Waste Management Branch of the B.C. Ministry of Environment)	The Act	The Act provides the Waste Management Branch with the legislative basis for overall management of industrial wastes for the protection of the environment. The Act was passed in 1982; however, as of 1987 no regulations had been promulgated.
	Section 3	A permit or approval from the Waste Management Branch is required to discharge a waste into the environment (applies to liquid effluent discharges, air emissions and solid wastes).
	Section 4	Storage of "special wastes" in excess of specified quantities must be authorized by a permit.
	Section 5	The generator or owner of a waste must complete a manifest form and meet other requirements before transporting special wastes.
	Section 10 Section 22	All industries that handle hazardous materials may be required to prepare a contingency plan. The Waste Management Branch can issue an "order" for a company to investigate the risk to the environment posed by its handling of a polluting substance or the environmental effects of a spill, or to conduct remedial and abatement measures.

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF PENTACHLOROPHENOL (Cont'd)

Legislative Act (Responsible Agency)	Relevant Sections	Comments
3.2 Environmental Management Act - B.C.	The Act Section 5 Section 6	Declaration of environmental emergency. Recovery of costs associated with environmental emergency.
3.3 Pesticide Control Act and Regulations (Pesticide Control Branch of the B.C. Ministry of Environment)	The Act	The Act and Regulations are designed to ensure that pesticides are sold and used safely according to label directions in a manner that will not produce an unreasonable adverse effect to the environment.
	The Regulations Section 4	The application of a pesticide on public land must be conducted by a certified pesticide applicator. A certified pesticide applicator has successfully completed a course and examination in a speciality field conducted by the Pesticide Control Branch.
	Section 28	There are no specific regulations for the control of PCP at wood preservation facilities.
3.4 Workers' Compensation Act Industrial Health and Safety Regulations - B.C. (Workers' Compensation Board (WCB))	The Act	The Act designates the WCB as responsible for the prevention of injuries and industrial diseases to workers at their place of employment. The Act empowers the WCB to make regulations that may apply to employers, workers and all persons working in or contributing to the production of any industry within the scope of the Act.
	8.18*	Adequate direction and instruction of workers.
	8.20	Supervisors are responsible for the proper instruction of workers under their direction and must ensure the work is performed without undue risk to the worker.
	12.01	Signs indicating the presence of hazardous chemicals at facilities.
	12.03	Storage of hazardous chemicals and design and labelling of containers.
	12.05	Emergency wash facilities.
	13.01	Exposure to airborne pentachlorophenol and measures to mitigate excessive exposure.
	13.05, 13.07	Tests to determine unsafe conditions.
	13.09	Protective measures where workers are in a confined space with unsafe atmosphere.
	13.07	Ventilation and testing for confined areas.
	13.37	Design of ventilation systems.
	13.43	Location of exhaust ventilation systems.

* Only certain regulations are highlighted. Many other regulations are applicable, including 8.02, 8.04, 8.22, 8.32, 8.52, 8.58, 8.72, 8.74, 8.84, 12.11, 13.41, 13.57, 14.01, 17.03, 17.05.

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF PENTACHLOROPHENOL (Cont'd)

Legislative Act (Responsible Agency)	Relevant Sections	Comments
3.4 Workers' Compensation Act Industrial Health and Safety Regulations, cont'd	13.47, 13.49	Restrictions on the recirculation of contaminated exhaust air.
	14.16, 14.18, 14.21	Protective equipment for workers handling treatment chemicals or treated lumber.
	14.23	Provisions for respiratory protection equipment.
	68.46	Special procedures for dealing with fires involving PCP.
	76.29	Chemical spills shall be cleaned up under the supervision of persons who are knowledgeable of the hazards of such spills and the precautions to be taken.
4. Manitoba		
4.1 Dangerous Goods Handling and Transportation Act and Regulations (Environment and Workplace Safety and Health)	Section 8 Section 9 Section 12 Section 31 Section 32	The Act was proclaimed August 1984 and provides the legislative basis covering all aspects of handling dangerous goods including their manufacture, use, storage, transportation and disposal. Sections 31 and 32 cover penalty provisions and offences. Section 40 provides provincial government the authority to develop regulations.
4.2 Clean Environment Act and Regulations - Environment and Workplace Safety and Health	Section 14	A proposal must be filed with the department for the establishment of any operation that will release contaminants into the air, water or soil. Subsequently, the operation will receive a Clean Environment Commission order setting out limits, terms and conditions for the process. In the absence of a central hazardous waste management system and facility, such an order will be required for the operation of a wood preservation facility in Manitoba. NOTE: This legislation is in the process of change - but approval will still be required.
5. Ontario		
5.1 Dangerous Goods Transportation Act (Ministry of Transportation and Communications)		The Act permits the Ministry to enact regulations to supplement those promulgated under the Federal Transportation of Dangerous Goods Act.

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF PENTACHLOROPHENOL (Cont'd)

Legislative Act (Responsible Agency)	Relevant Sections	Comments
5.2 Environmental Protection Act (Ministry of the Environment)		The Act provides the legislative basis for the protection of the environment.
	Sections 12 and 14	The Ministry of the Environment must be notified if a discharge is greater than the permitted level, or is likely to harm the environment.
	Sections 80 and 81	Spills likely to harm the environment must be reported to the Ministry, the municipality and company management. Remedial action must be taken.
	Section 84	Disposal of spilled material may be regulated by the Ministry.
	Section 136(1)	The Ministry may regulate the discharge of a contaminant or the modification of waste treatment facilities.
	Section 136(7)	Any occurrence in compliance with the Ontario Water Resources Act or the Pesticides Act is not a "spill".
Air Pollution (Control) Regulations	Section 9	The Ministry must be consulted if a process upset results in excessive emissions.
	Section 10 Also Section 6	The use of treated wood wastes in a boiler is legally questionable.
Spills Regulations		Sets out procedures for compensation of persons affected by a spill; but only if the Pesticides Act and other applicable federal, provincial and municipal legislation has not been complied with.
Waste Management General Regulation	Section 15	Generators of waste must be registered with the Ministry.
	Section 16, 20-23	Waste must be properly disposed of, and all prescribed manifests kept.
	Schedules 1 and 2	Sludge from the effluent treatment plant is a hazardous industrial waste.
Guidelines for Environmental Protection Measures at Chemical Storage Facilities		Code of good practice for storage tanks.
5.3 Health Protection and Promotion Act (Ministry of Health)		The medical officer of health may inspect, receive complaints and issue orders or directions in case of a health hazard.
5.4 Lakes and Rivers Improvement Act (Ministry of Natural Resources)		The Act provides for the protection of water bodies and for their equitable public and private use.
	Sections 37 and 38	The Ministry of Natural Resources may order a mill not to discharge any refuse, sawdust, chemical, etc.
	Also Section 39	

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF PENTACHLOROPHENOL (Cont'd)

Legislative Act (Responsible Agency)	Relevant Sections	Comments
5.5 Ontario Water Resources Act (Ministry of the Environment)		The Act provides for the preservation of water purity, and governs the operation of water and sewage works.
	Sections 14-16	Discharge of any substance that may impair water quality is prohibited, and an ex parte injunction may be obtained against it.
	Section 18	The Minister may order the maintenance of equipment or chemicals necessary to alleviate impairment of water quality.
5.6 Pesticides Act (Ministry of the Environment)		The Act regulates the elimination of pests, and all use and handling of pesticides.
	Section 4	The use of a pesticide such that excessive harm is caused to the environment is prohibited.
	Section 28	Provides for the enactment of regulations governing the transportation, handling, storage and use of pesticides, the type, labelling and disposal of containers, and decontamination.
	Also Sections 20, 21 and 23	
Pesticides (General) Regulations	Section 24	A pesticide must be kept in the proper container, which must be properly labelled.
	Sections 25 and 26	Empty pesticide containers must be properly disposed of, damaged containers must be replaced or disposed of and spillage cleaned up.
	Section 27	If a pesticide is involved in a fire, theft or other unusual occurrence, the Director (Pesticides, MOE) must be notified.
	Section 98	Pesticides must be kept away from human or animal food.
	Section 99	Pesticides on schedules 1, 2 and 5 must be stored in a room which is vented to the outside, with doors marked "Chemical Storage - Authorized Persons Only" and which is accessible only to authorized persons.
	Also Sections 105 and 106	

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF PENTACHLOROPHENOL (Cont'd)

Legislative Act (Responsible Agency)	Relevant Sections	Comments
5.7 Occupational Health and Safety Act (Ministry of Labour)		The Act governs protection of health and safety in the work place.
	Sections 14-17	Employer shall provide necessary equipment, educate workers, disclose all hazards, maintain occupational health service, keep records of chemicals used, including exposure records. The use of new chemicals must be reported, the levels of chemicals must be monitored and kept below a prescribed level. Supervisor must ensure that workers comply with health and safety procedures. Workers must use protective equipment provided, and inform the employer of any unsafe situations.
	Section 20	The Ministry may regulate the use of, and exposure to any toxic substances.
	Section 41 (1) and (2)	Provides for the specific regulation of exposure to chemicals.
	Also Sections 23, 24, and 28-33	
Industrial Establishments Regulations	Section 66 (1)	Piping containing a hazardous substance shall be labelled at valves, fittings, etc.
	Sections 83, 85 and 88	Workers must be provided with equipment protecting them from skin and eye injury, and be trained in its use.
	Setions 128 and 129	Eyewash fountains and deluge showers must be provided.
	Sections 131 and 132	Work place must be adequately ventilated.
	Sections 134 and 135	Workers shall be trained in the use of chemicals, use of protective equipment and emergency procedures. Food, drink and tobacco not permitted near poisonous substances.
	Section 145	All measures necessary to prevent exposure to toxic substances shall be taken.
	Also Sections 14, 15, 26, 27, 71-74, 139, 141(b), and 142	
Regulations Concerning Exposure to Chemical and Biological Agents		

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF PENTACHLOROPHENOL (Cont'd)

Legislative Act (Responsible Agency)	Relevant Sections	Comments
6. Quebec		
6.1 Loi sur la qualité de l'environnement (Environmental Protection Act) (Ministry of Environment)	Article 1	Contaminants are defined in the following manner: a solid liquid or gas, or any combination of these that could alter in some manner the quality of the environment.
	Article 20	This article states that no person may emit, dispose of, release or discharge, or permit the emission, disposal, release or discharge, into the environment of a contaminant that could affect human life, health, safety, security, welfare or comfort, or cause damage or otherwise compromise the quality of soil, vegetation, wildlife or property.
	Article 21	The Deputy Minister of the Environment must be notified immediately of any incident that causes the presence of a contaminant in the environment.
	Hazardous Wastes Regulation (A.C. 1000-85)	This regulation defines bottom sediment sludges from the treatment of wastewaters from wood preserving processes that use creosote, pentachlorophenol or inorganic components containing arsenic, as being a category of hazardous wastes.
	Solid Waste Regulations (R.R.Q. 1981, C.Q. - 2, r.14)	Any leachate containing contaminants (chromium, copper, phenolic compounds) above the standards prescribed must not be discharged into the hydrographic surface network or into a storm water sewer.
6.2 Loi sur la santé et la sécurité du travail (Occupational Health and Safety Commission) (L.R.Q., chap. S-2.1)		This act establishes mechanisms to permit the participation of workers and employers in the elimination of causes of accidents and occupational illnesses. The act gives to workers the right to take leave if exposure to a contaminant poses a danger to them, as evidenced by signs of health effects.
	Industrial and Commercial Establishments Regulation (R.R.Q. 1981, chap. S-2.1 r.9)	This regulation prescribes general standards of health and safety for industrial and commercial premises. The scope of application includes the state of workplaces, working conditions such as ventilation, lighting, noise and vibration, control of hazardous substances and radiation, equipment and individual protection.
	Regulation on the Quality of the Workplace (R.R.Q. 1981, chap. S-2.1, r.15)	This regulation applies to the presence of dust, gases, fumes and vapours, lighting, temperature, noise, ventilation, etc.
6.3 Code de la sécurité (Highway Safety Code) (Ministry of Transport)	Transport of Dangerous Substances Regulation (C-24.1, r.19.01)	This regulation protects the public during the transport of dangerous goods. Documentation, packing, and signing for dangerous goods are specified.

TABLE A.2 EMERGENCY CONTACTS (PCP Treatment Facilities)

Emergency Incident	Emergency Contact
Spills to marine waters	Environment Canada - Local office
Spills to freshwaters containing anadromous fish (e.g. salmon) or Spills on federal or indian lands	Environment Canada - Local office and Provincial Emergency Program - Local office
Spills to land during transport (More than 5 kilograms or 5 litres of PCP or PCP wastes)	Provincial Emergency Program - Local office
Ingestion of PCP or exposure to high concentrations of PCP	Local Hospital and Poison Control Center (additional information)
Fire	Local Fire Department
Emergency response information	PCP Suppliers * May and Baker (416) 821-4450 * Vulcan Materials Co. (205) 877-3000

TABLE A.3 GENERAL INFORMATION CONTACTS (PCP Treatment Facilities)

Subject	Contact
Compliance with Federal Environmental Legislation	Environment Canada - Local office
Transport of Dangerous Goods Act (Questions of consignors, manufacturers, consignees, warehousers, freight forwarders, brokers, etc.)	Local Regional Inspector Transport of Dangerous Goods Transport Canada
Railway Transport	Local Dangerous Goods Coordinator and Chief, Operations Railway Transport Committee
Transport of Dangerous Goods Road Transport	Local Director, Administrator and Road Safety Motor Vehicle Department